BETHLEHEM
STRUCTURAL
SHAPES

BETHLEHEM STRUCTURAL SHAPES

Catalogue S-18

BETHLEHEM STEEL COMPANY
GENERAL OFFICES: BETHLEHEM, PA.

NOTICE.

This catalogue presents useful information relating to Bethlehem Structural Shapes, comprising tables of dimensions, weights, properties and other data, together with explanatory notes, all of which are revised to date.

The sections of Bethlehem Girders and I Beams shown herein have been improved, in design and proportions, at various times during recent years, to provide a still more economical use of material. The method of accomplishing these betterments is fully described in the following Explanatory Notes.

In computing the weights of all the sections, additions for fillets have been included, in conformity with the established practice adopted by the Association of American Steel Manufacturers.

The dimensions and weights presented herein are theoretical and subject to the usual variations.

All of the sections are numbered throughout for convenience in identification and ordering

BETHLEHEM STEEL COMPANY.

Bethlehem, Pennsylvania
March, 1926.

Copyright, 1926, Bethlehem Steel Company.

EXPLANATORY NOTES.

The purpose of this catalogue is to supply information and tables regarding steel constructions in which wide flange Bethlehem Structural Steel Shapes are employed.

Improved Bethlehem Structural Shapes. Since the inception of the manufacture of Bethlehem Wide Flange Structural Shapes in 1908, various additions have been made from time to time and improvements adopted in the design and proportions of the series of Bethlehem Girders and Bethlehem I Beams. New column sections have also been added.

Improvements made since 1921 in the Bethlehem Girders and I Beams, consist in modifications of their profiles in such a way that, in the various series, the intermediate and heavier weights of each size are produced by adding material both to the flanges and the web of the minimum section, resulting in further economies.

These series of wide flange sections are protected by United States Letters Patent.

Method of Rolling. In order to produce these wide flange Bethlehem Shapes a Grey Universal Structural Mill is used, which has both horizontal and vertical rolls, forming the web and flanges of each section by coincident rolling operations. By the use of such a mill, these sections can be produced with very wide flanges, which provide additional strength and stiffness in all directions. The general arrangement of the Grey Mill rolls is as shown in Figs. 1 and 2 below.

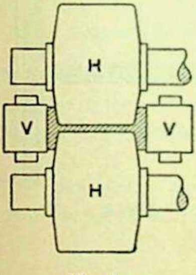


Fig. 1.

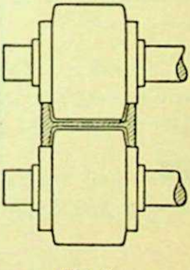


Fig. 2.

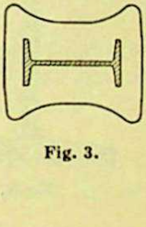


Fig. 3.

During the rolling of a section the horizontal rolls, H, and the vertical rolls, V, as shown in Fig. 1, are brought proportionately closer together at each successive passage of the material through the rolls.

Fig. 2 represents a supplementary mill through which the partially rolled section passes, the purpose of which is to edge the flanges only, no other work being done in this secondary mill. This adds materially to the finish of the profile.

For large beams and girders the ingot is cast of rudimentary I beam shape, as shown by Fig. 3. The outer line of the Figure represents the shape of the ingot and within this is shown the finished section, both being drawn to scale. By successive reductions the ingot is rolled into a girder or beam of the desired dimensions.

Variation in Profiles and Weights. Attention is called to the manner in which the variation in profiles and weights of Bethlehem Structural Shapes is obtained by increasing or decreasing the thickness of the flange, as well as that of the web, as shown in Figs. 4 and 5.

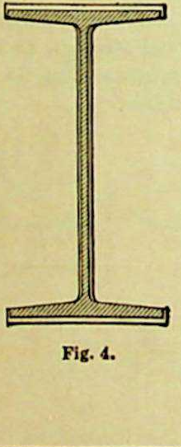


Fig. 4.

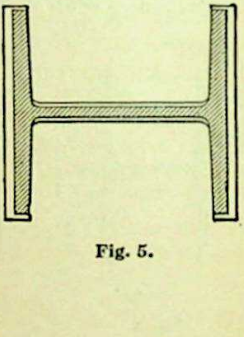


Fig. 5.

In 1921, this method was successfully applied to Bethlehem I Beam sections B18a, B22, and B24b, and since then it has been extended to all Bethlehem Girder Beams. More recently, this method has been adopted in producing all Bethlehem I Beams, so that now it applies to all Bethlehem Structural Shapes.

Advantages of Bethlehem Wide Flange Shapes. These shapes can be used for every purpose for which I sections are adapted and they can also take the place of riveted sections with economy in weight or saving in cost of fabrication, and in most cases with saving both in weight and fabricating cost.

The wide flanges give increased lateral stiffness and also afford ample surfaces for bearing and connections.

Bethlehem I Beams and Girder Beams can be advantageously used as girders for buildings, crane runways, short span bridges, bridge floor beams, and for many other purposes where otherwise the more expensive types of riveted girders would be required.

In the design of these sections the modification of the profiles of each size, by adding material to the flanges and a lesser amount to the web, provides economy of material for the following reason:—A substantially rectangular area added to the outside of the flange increases the Moment of Inertia or Section Modulus, about the axis perpendicular to the web, to an extent three times as great as the addition of a similar area to the web. This is in accordance with the principles of structural mechanics.

Bethlehem Girder Beams. In general, three weights are provided for each section, to give opportunities for the selection of the proper and economical size for any required purpose.

The necessary modifications in profiles were made in the Girder sections in 1922, by adding material to the flanges and a lesser amount to the web as previously described.

This method of rolling provides series of sections in which the Section Modulus is practically proportional to the variation in weight. Thus G12, 61 pounds per foot, compared with G12, 55.5 pounds per foot, has an increase of 7.2 in Section Modulus, or about 10 per cent increase in modulus, due to the increase of 5.5 pounds per foot, which is also about 10 per cent increase in weight. The increase or decrease in the flange thickness is made at the outside of the flange, thereby slightly varying the depth of the Girder Beam; but the total variation in depth from the minimum to the maximum for each section is not more than the usual allowable tolerance in depth necessary in any method of rolling beams.

Bethlehem I Beams. All Bethlehem I Beams, comprising the entire series from 8-inch to 30-inch inclusive, have had their sections modified in the same manner as that used to provide the different weights of each size of Bethlehem Girder Beams. By this method, the addition of area, to provide the different weights of each size, increases the Section Modulus and strength practically in direct proportion to the increase of weight.

Bethlehem Columns. All column shapes having the same section number are made by the same set of rolls. Thus, for example:—the 14-inch H Columns, comprising all the weights and variations in size of sections shown on page 56, are from the same set of rolls, furnishing a series of rolled columns of similar profile. Columns can thus be selected of the proper areas to suit variations of load, affording a wide range of sizes from the same rolling and insuring prompt delivery.

The only fabrication required for these columns is that necessary to provide for splices and connections. In the case of columns with thick metal, the holes require drilling, which can be done economically with a multiple drill. The saving in cost of fabricating these rolled columns as compared with built-up riveted columns is a great advantage in favor of the solid rolled shapes. Sections can be spliced, to make a practically continuous column, and connections are easily made in the most approved manner of the best structural practice. All the surfaces of the column are accessible for painting.

Tables of dimensions and properties of 14-inch H Columns reinforced with cover plates are given on pages 70 and 71. These are used when columns are required of greater sectional area than the largest integral 14-inch H Column rolled. Dimensions and properties of heavy columns, made of a Bethlehem 14-inch Special H Section with cover plates, are given on pages 72 and 73.

Bethlehem Column Sections are increased in area and weight, as shown in Fig. 5, by spreading both sets of rolls; the thickness of the web and the width of the flanges are increased equally, the thickness of the flange being increased by a proportionate amount.

Supplementary Sections. Supplementary Columns are provided, which are lighter than the regular H Columns, thus furnishing another series, adapted for smaller loads. These Supplementary Columns are also particularly useful in shop and mill building construction. The smallest of these is a 6-inch column which is especially adapted to light construction.

Slope of Flanges. The slope of the flanges of all Bethlehem Girder Beams and I Beams is 8⅓ per cent or 1 in 12, and the slope of the flanges of all Bethlehem Columns is 2 per cent or 1 in 50.

Weights. Weights of rolled steel sections are calculated on the basis of 489.6 pounds per cubic foot; and 3.4 times the sectional area, in square inches, equals the weight in pounds per lineal foot.

Variations. The dimensions, areas and weights of all rolled steel sections shown herein are theoretical only and subject to customary variations.

All sections shown herein are steel.

GENERAL CONDITIONS.

Allowable Variations. Shapes will be cut to ordered length with an allowable variation either way, as follows:—

> Bethlehem I Beams 8 inches to 24 inches deep, inclusive, within ⅜ inch; all other sections, within ½ inch.

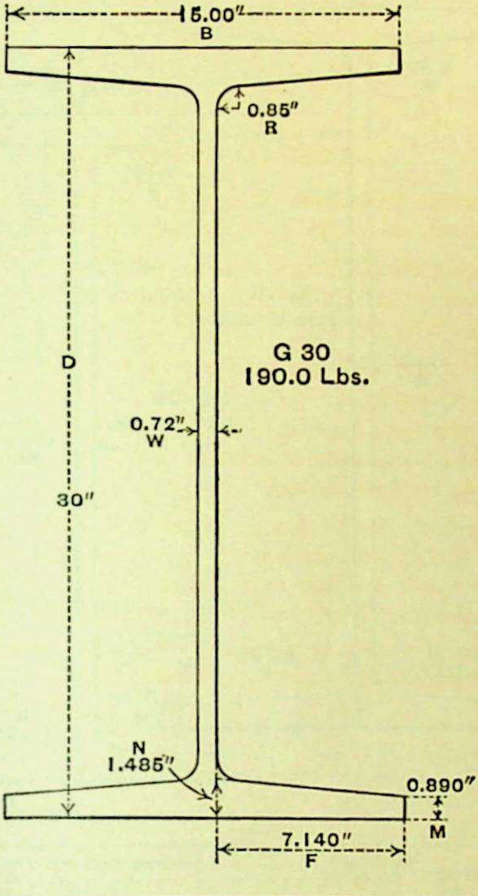
For cutting with less variation, or to exact length, an extra price is charged.

Sections are furnished only at catalogue weights. Shapes may have an allowable variation of 2½ per cent either way from the nominal section.

Material. All Bethlehem Structural Shapes are of open hearth steel exclusively, conforming to Manufacturers' Standard specifications; and also to American Railway Engineering and Maintenance of Way Association specifications.

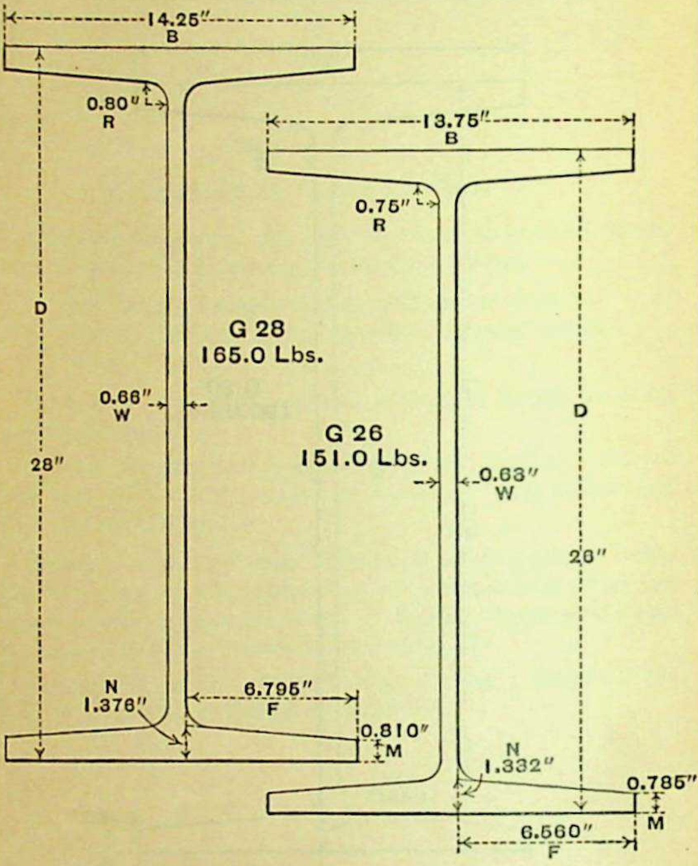
Material complying with any other standard specifications may be furnished by special arrangement.

BETHLEHEM GIRDER BEAMS.



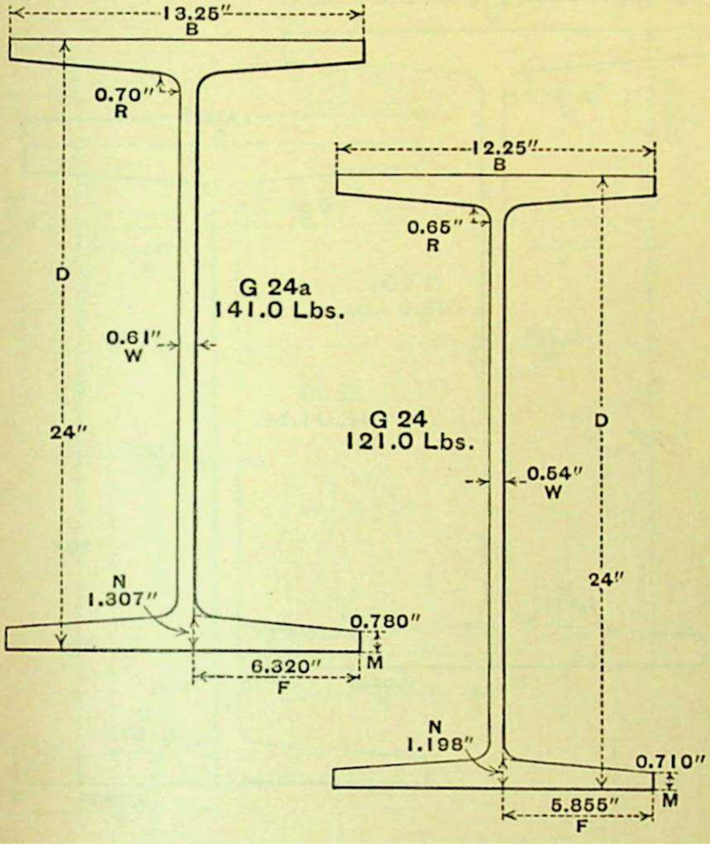
Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
G30	200.0	30⅛	30.12	15.04	.760	.950	1.545	7.140	.85
	190.0	**30**	**30.00**	**15.00**	**.720**	**.890**	**1.485**	**7.140**	**.85**
	181.0	29⅞	29.88	14.97	.690	.830	1.425	7.140	.85

BETHLEHEM GIRDER BEAMS.



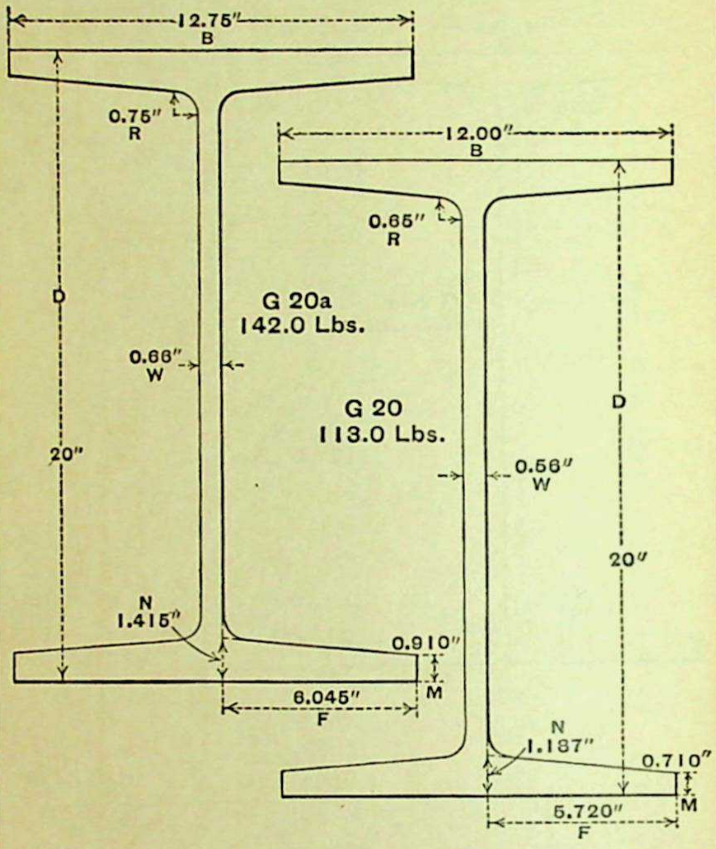
Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
G28	175.0	28⅛	28.12	14.29	.700	.870	1.436	6.795	.80
	165.0	**28**	**28.00**	**14.25**	**.660**	**.810**	**1.376**	**6.795**	**.80**
G26	160.0	26⅛	26.12	13.79	.670	.845	1.392	6.560	.75
	151.0	**26**	**26.00**	**13.75**	**.630**	**.785**	**1.332**	**6.560**	**.75**
	144.0	25⅞	25.88	13.73	.610	.725	1.272	6.560	.75

BETHLEHEM GIRDER BEAMS.



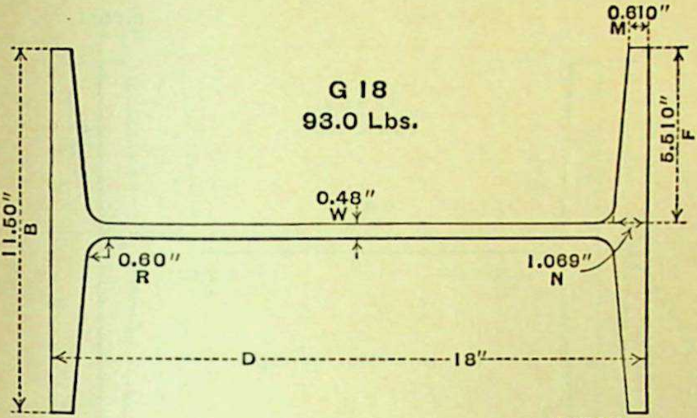
Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
	149.0	24⅛	24.12	13.29	.650	.840	1.367	6.320	.70
G24a	**141.0**	**24**	**24.00**	**13.25**	**.610**	**.780**	**1.307**	**6.320**	**.70**
	133.0	23⅞	23.88	13.22	.580	.720	1.247	6.320	.70
	129.0	24⅛	24.12	12.29	.580	.770	1.258	5.855	.65
G24	**121.0**	**24**	**24.00**	**12.25**	**.540**	**.710**	**1.198**	**5.855**	**.65**
	114.0	23⅞	23.88	12.22	.510	.650	1.138	5.855	.65

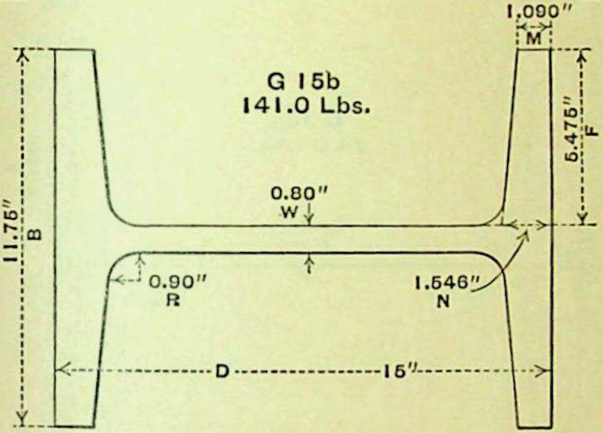
BETHLEHEM GIRDER BEAMS.



Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
G20a	149.0	20⅛	20.12	12.78	.690	.970	1.475	6.045	.75
	142.0	**20**	**20.00**	**12.75**	**.660**	**.910**	**1.415**	**6.045**	**.75**
	135.0	19⅞	19.88	12.72	.630	.850	1.355	6.045	.75
G20	120.0	20⅛	20.12	12.03	.590	.770	1.247	5.720	.65
	113.0	**20**	**20.00**	**12.00**	**.560**	**.710**	**1.187**	**5.720**	**.65**
	107.0	19⅞	19.88	11.98	.540	.650	1.127	5.720	.65

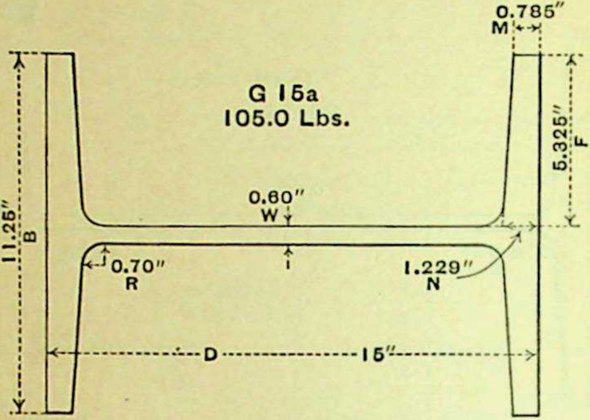
BETHLEHEM GIRDER BEAMS.

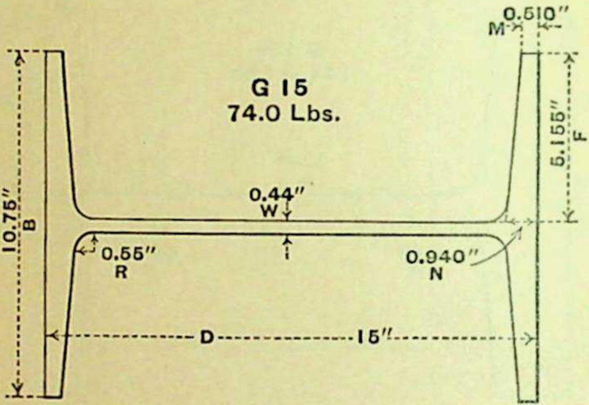




Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
	100.0	18⅛	18.12	11.54	.520	.670	1.129	5.510	.60
G18	**93.0**	**18**	**18.00**	**11.50**	**.480**	**.610**	**1.069**	**5.510**	**.60**
	87.5	17⅞	17.88	11.48	.460	.550	1.009	5.510	.60
	147.0	15⅛	15.12	11.78	.830	1.150	1.606	5.475	.90
G15b	**141.0**	**15**	**15.00**	**11.75**	**.800**	**1.090**	**1.546**	**5.475**	**.90**
	135.0	14⅞	14.88	11.72	.770	1.030	1.486	5.475	.90

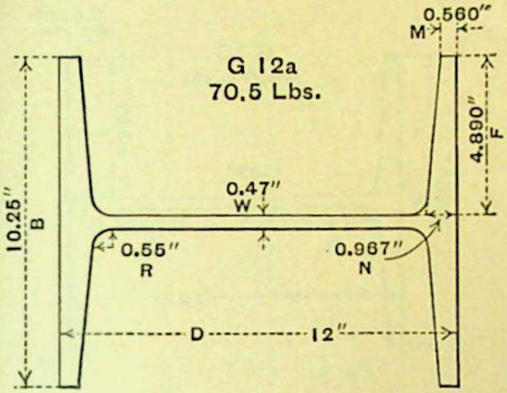
BETHLEHEM GIRDER BEAMS.

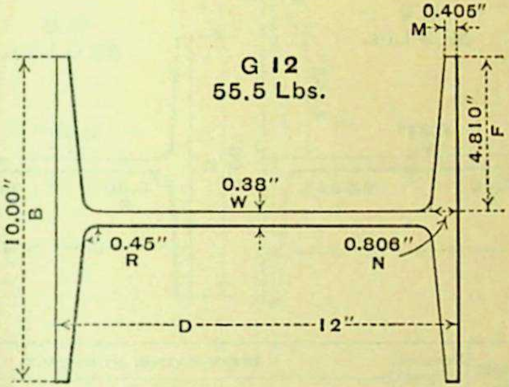




Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
G15a	111.0	15⅛	15.12	11.29	.640	.845	1.289	5.325	.70
	105.0	**15**	**15.00**	**11.25**	**.600**	**.785**	**1.229**	**5.325**	**.70**
	99.0	14⅞	14.88	11.22	.570	.725	1.169	5.325	.70
G15	80.5	15⅛	15.12	10.79	.480	.570	1.000	5.155	.55
	74.0	**15**	**15.00**	**10.75**	**.440**	**.510**	**.940**	**5.155**	**.55**
	69.0	14⅞	14.88	10.73	.420	.450	.880	5.155	.55

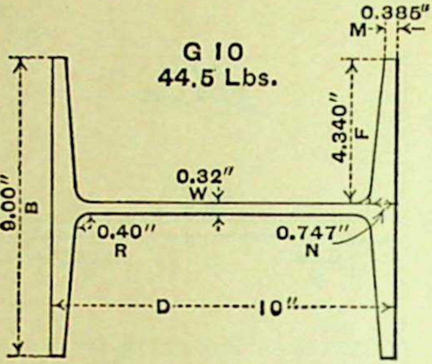
BETHLEHEM GIRDER BEAMS.

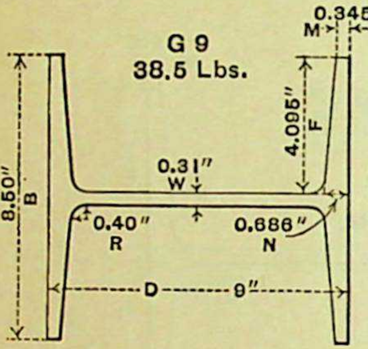


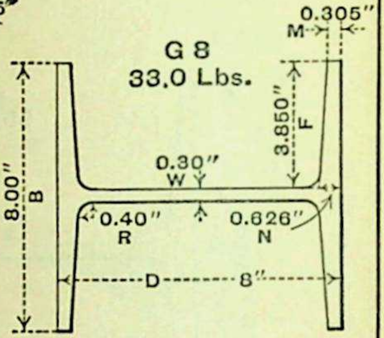


Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
	76.5	12⅛	12.12	10.29	.510	.620	1.027	4.890	.55
G12a	**70.5**	**12**	**12.00**	**10.25**	**.470**	**.560**	**.967**	**4.890**	**.55**
	66.0	11⅞	11.88	10.23	.450	.500	.907	4.890	.55
	61.0	12⅛	12.12	10.03	.410	.465	.866	4.810	.45
G12	**55.5**	**12**	**12.00**	**10.00**	**.380**	**.405**	**.806**	**4.810**	**.45**
	51.5	$11\frac{29}{32}$	11.91	9.98	.360	.360	.761	4.810	.45

BETHLEHEM GIRDER BEAMS.

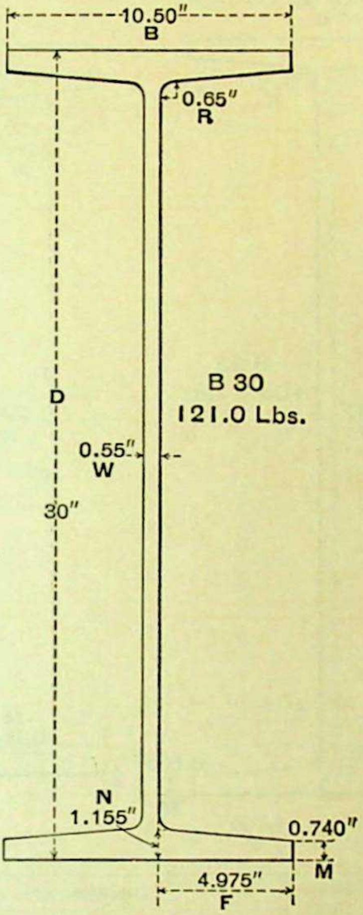






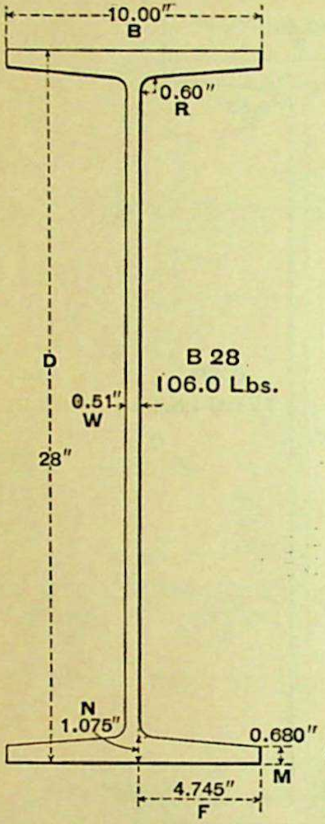
Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
G10	50.0	10⅛	10.12	9.04	.360	.445	.807	4.340	.40
	44.5	**10**	**10.00**	**9.00**	**.320**	**.385**	**.747**	**4.340**	**.40**
	41.5	9²⁹⁄₃₂	9.91	8.99	.310	.340	.702	4.340	.40
G9	43.5	9⅛	9.12	8.54	.350	.405	.746	4.095	.40
	38.5	**9**	**9.00**	**8.50**	**.310**	**.345**	**.686**	**4.095**	**.40**
	36.0	8¹⁵⁄₁₆	8.94	8.48	.290	.315	.656	4.095	.40
G8	37.0	8⅛	8.12	8.03	.330	.365	.686	3.850	.40
	33.0	**8**	**8.00**	**8.00**	**.300**	**.305**	**.626**	**3.850**	**.40**
	31.0	7¹⁵⁄₁₆	7.94	7.99	.290	.275	.596	3.850	.40

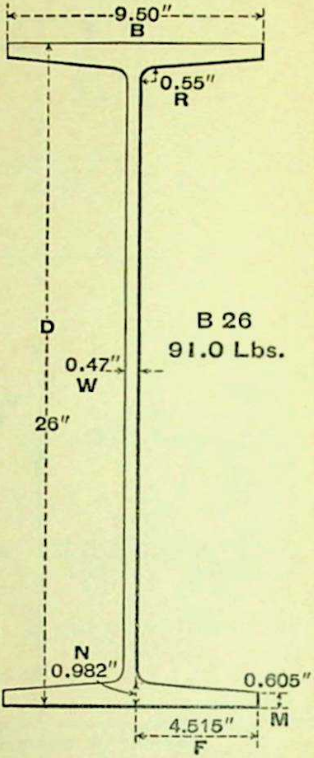
BETHLEHEM I BEAMS.



Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B30	129.0	30⅛	30.12	10.53	.580	.800	1.215	4.975	.65
	121.0	**30**	**30.00**	**10.50**	**.550**	**.740**	**1.155**	**4.975**	**.65**
	115.0	29⅞	29.88	10.48	.530	.680	1.095	4.975	.65

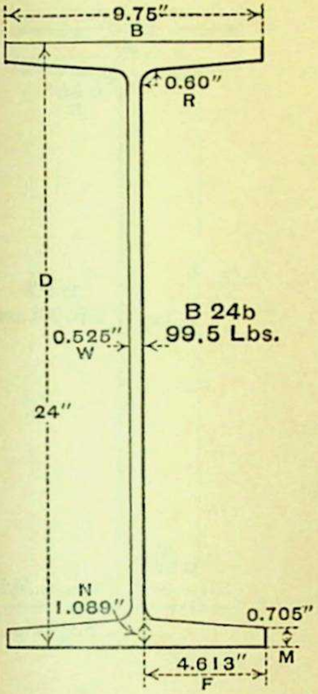
BETHLEHEM I BEAMS.

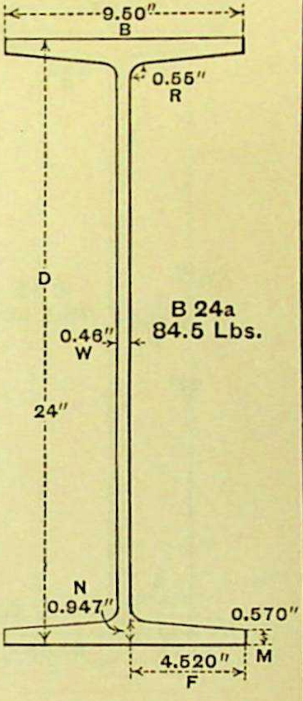




Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B28	113.0	28⅛	28.12	10.03	.540	.740	1.135	4.745	.60
	106.0	**28**	**28.00**	**10.00**	**.510**	**.680**	**1.075**	**4.745**	**.60**
	100.0	27⅞	27.88	9.98	.490	.620	1.015	4.745	.60
B26	98.0	26⅛	26.12	9.53	.500	.665	1.042	4.515	.55
	91.0	**26**	**26.00**	**9.50**	**.470**	**.605**	**.982**	**4.515**	**.55**
	85.5	25⅞	25.88	9.48	.450	.545	.922	4.515	.55

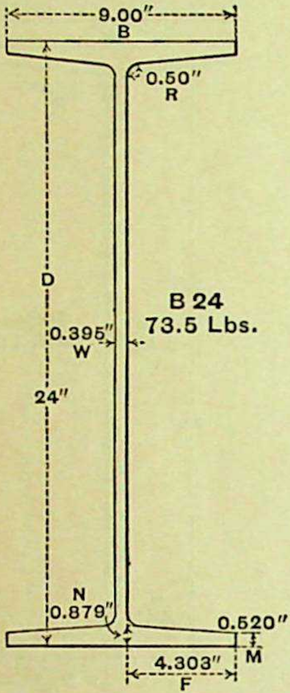
BETHLEHEM I BEAMS.

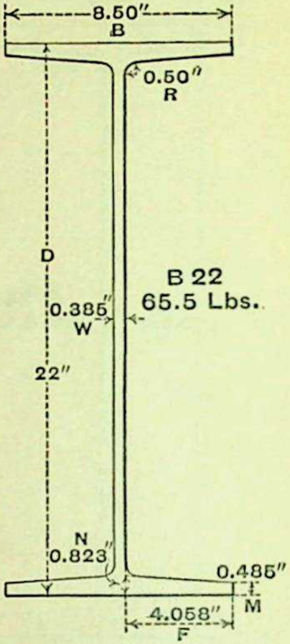




Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B24b	104.5	$24\frac{3}{32}$	24.09	9.775	.550	.750	1.134	4.613	.60
	99.5	**24**	**24.00**	**9.750**	**.525**	**.705**	**1.089**	**4.613**	**.60**
	95.5	$23\frac{29}{32}$	23.91	9.730	.505	.660	1.044	4.613	.60
B24a	**84.5**	**24**	**24.00**	**9.500**	**.460**	**.570**	**.947**	**4.520**	**.55**

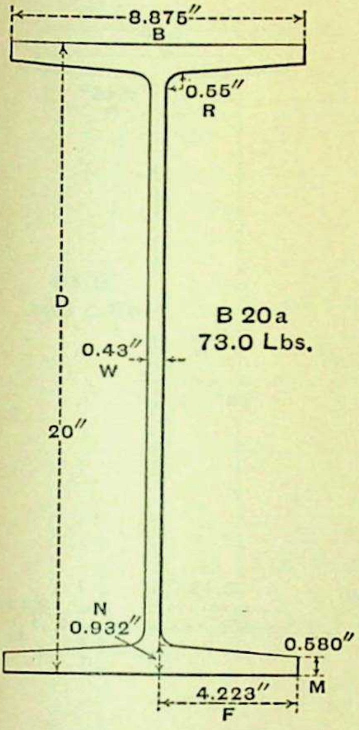
BETHLEHEM I BEAMS.

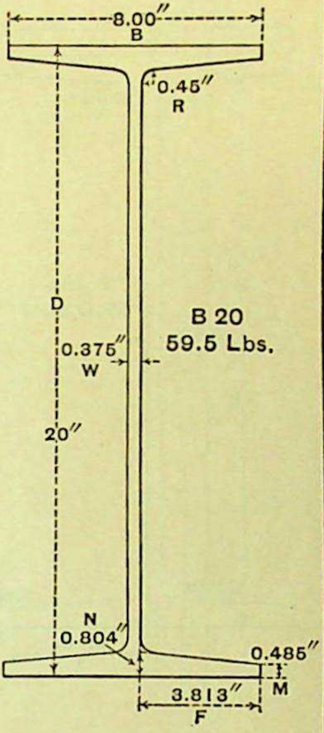




Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B24	79.5 **73.5**	$24\frac{3}{32}$ **24**	24.09 **24.00**	9.035 **9.000**	.430 **.395**	.565 **.520**	.924 **.879**	4.303 **4.303**	.50 **.50**
B22	71.5 68.5 **65.5**	$22\frac{1}{8}$ $22\frac{1}{16}$ **22**	22.12 22.06 **22.00**	8.535 8.520 **8.500**	.420 .405 **.385**	.545 .515 **.485**	.883 .853 **.823**	4.058 4.058 **4.058**	.50 .50 **.50**

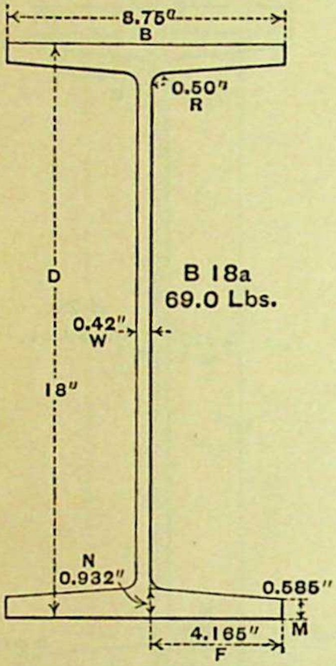
BETHLEHEM I BEAMS.

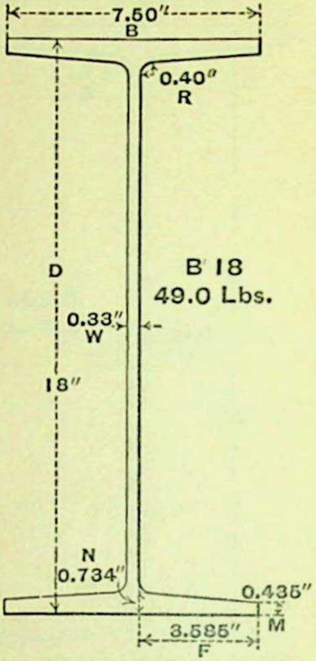




Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B20a	78.0	20 3/32	20.09	8.905	.460	.625	.977	4.223	.55
	73.0	**20**	**20.00**	**8.875**	**.430**	**.580**	**.932**	**4.223**	**.55**
B20	64.5	20 1/8	20.12	8.025	.400	.545	.864	3.813	.45
	62.0	20 1/16	20.06	8.015	.390	.515	.834	3.813	.45
	59.5	**20**	**20.00**	**8.000**	**.375**	**.485**	**.804**	**3.813**	**.45**

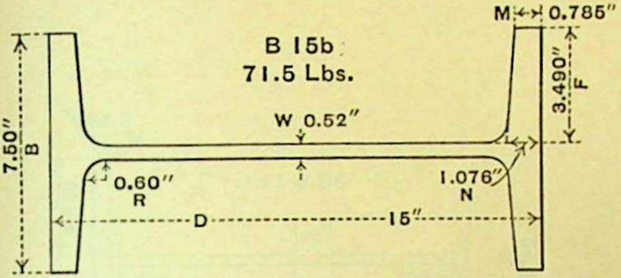
BETHLEHEM I BEAMS.

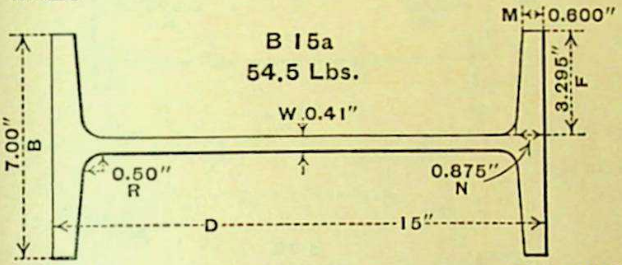


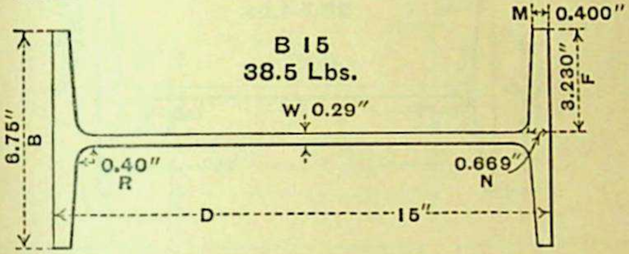


Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B18a	74.0	18⅛	18.12	8.770	.440	.645	.992	4.165	.50
	69.0	**18**	**18.00**	**8.750**	**.420**	**.585**	**.932**	**4.165**	**.50**
	64.5	17⅞	17.88	8.730	.400	.525	.872	4.165	.50
B18	54.5	18⅛	18.12	7.540	.370	.495	.794	3.585	.40
	52.0	18¹⁄₁₆	18.06	7.525	.355	.465	.764	3.585	.40
	49.0	**18**	**18.00**	**7.500**	**.330**	**.435**	**.734**	**3.585**	**.40**

BETHLEHEM I BEAMS.

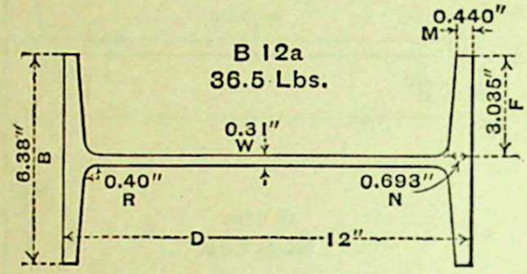


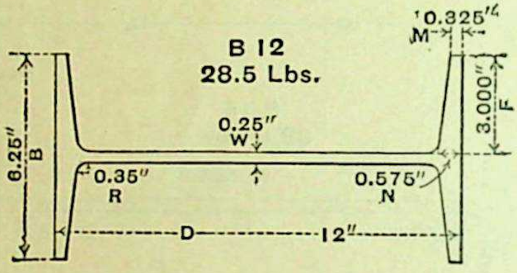




Section Number.	Weight per Foot, Pounds	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B15b	**71.5**	**15**	**15.00**	**7.500**	**.520**	**.785**	**1.076**	**3.490**	**.60**
	59.5	$15\frac{1}{8}$	15.12	7.040	.450	.660	.935	3.295	.50
B15a	**54.5**	**15**	**15.00**	**7.000**	**.410**	**.600**	**.875**	**3.295**	**.50**
	50.5	$14\frac{7}{8}$	14.88	6.975	.385	.540	.815	3.295	.50
	42.5	$15\frac{3}{32}$	15.09	6.785	.325	.445	.714	3.230	.40
B15	40.0	$15\frac{1}{32}$	15.03	6.765	.305	.415	.684	3.230	.40
	38.5	**15**	**15.00**	**6.750**	**.290**	**.400**	**.669**	**3.230**	**.40**

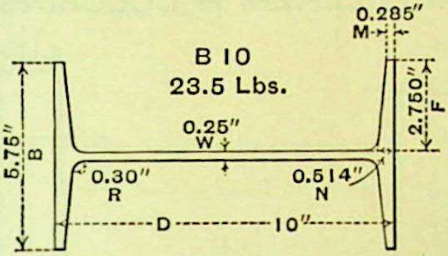
BETHLEHEM I BEAMS.

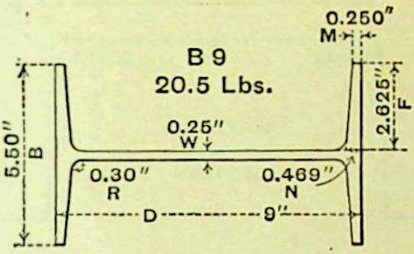


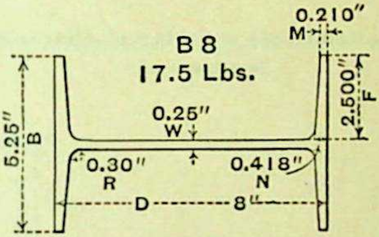


Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B12a	**36.5**	**12**	**12.00**	**6.380**	**.310**	**.440**	**.693**	**3.035**	**.40**
B12	31.0	12 1/16	12.06	6.270	.270	.355	.605	3.000	.35
	28.5	**12**	**12.00**	**6.250**	**.250**	**.325**	**.575**	**3.000**	**.35**

BETHLEHEM I BEAMS.

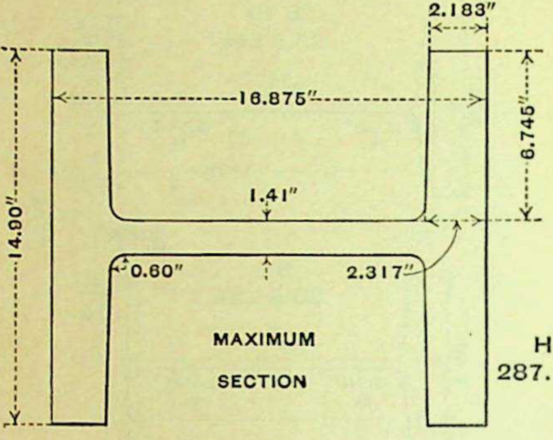






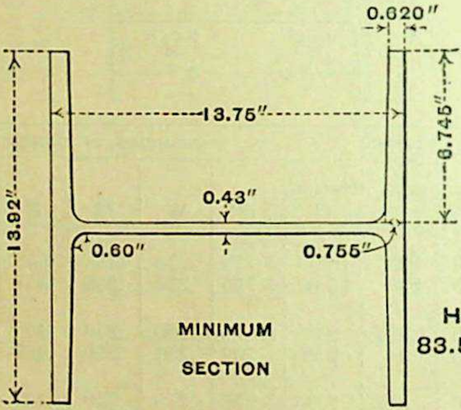
Section Number.	Weight per Foot, Pounds.	Nominal Depth of Beam, Inches.	DIMENSIONS, IN INCHES.						
			Nominal D	B	W	M	N	F	R
B10	26.0	10$\frac{3}{32}$	10.09	5.770	.270	.330	.559	2.750	.30
	23.5	**10**	**10.00**	**5.750**	**.250**	**.285**	**.514**	**2.750**	**.30**
B9	22.0	9$\frac{1}{16}$	9.06	5.510	.260	.280	.499	2.625	.30
	20.5	**9**	**9.00**	**5.500**	**.250**	**.250**	**.469**	**2.625**	**.30**
B8	19.0	8$\frac{1}{16}$	8.06	5.270	.270	.240	.448	2.500	.30
	17.5	**8**	**8.00**	**5.250**	**.250**	**.210**	**.418**	**2.500**	**.30**

BETHLEHEM H COLUMNS.



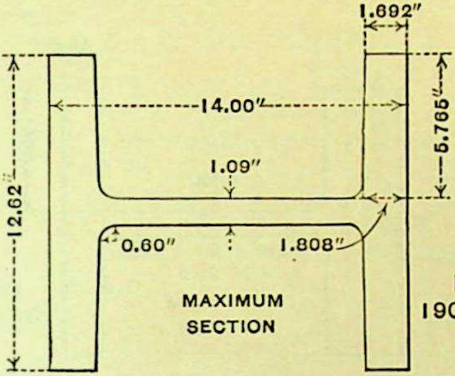
H 14
287.5 Lbs.

For intermediate weights and dimensions, see page 56.



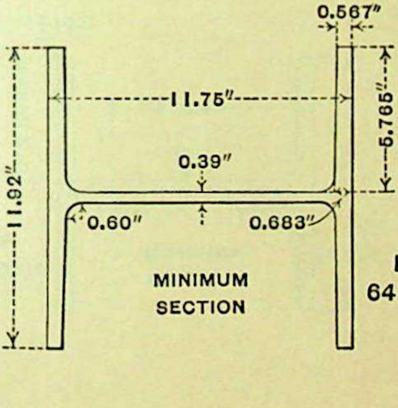
H 14
83.5 Lbs.

BETHLEHEM H COLUMNS.



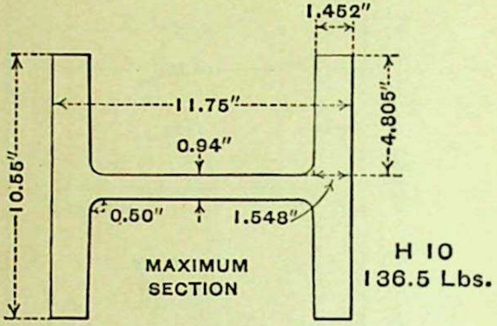
H 12
190.0 Lbs.

For intermediate weights and dimensions, see page 58.

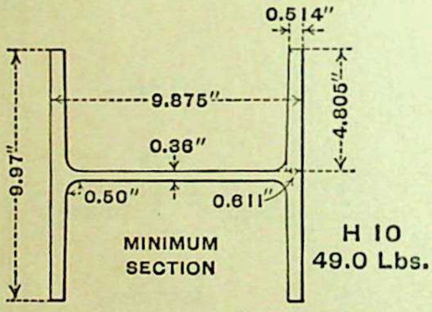


H 12
64.5 Lbs.

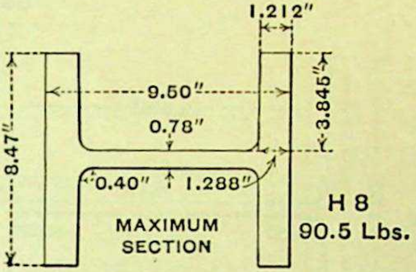
BETHLEHEM H COLUMNS.



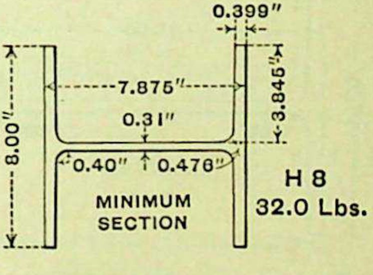
For intermediate weights and dimensions, see page 60.



BETHLEHEM H COLUMNS.

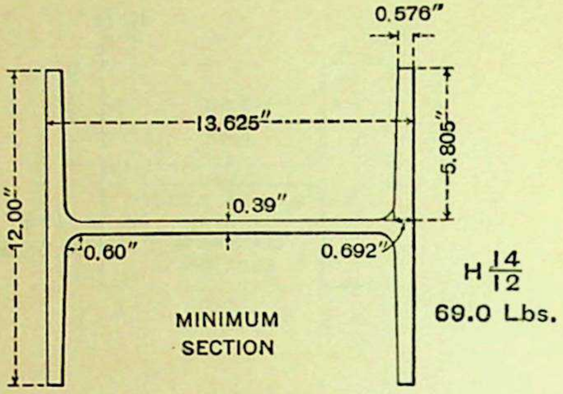


For intermediate weights and dimensions, see page 62.

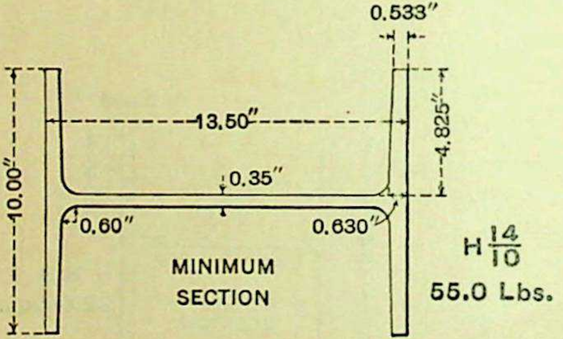


BETHLEHEM COLUMNS.

SUPPLEMENTARY SECTIONS.



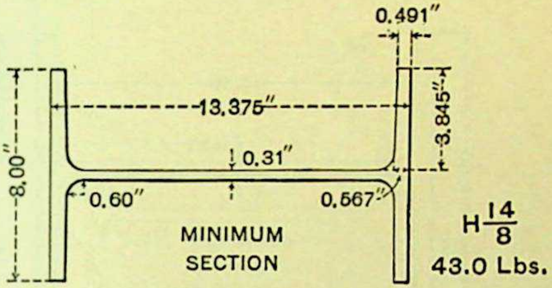
For increased weights and dimensions, see page 64.



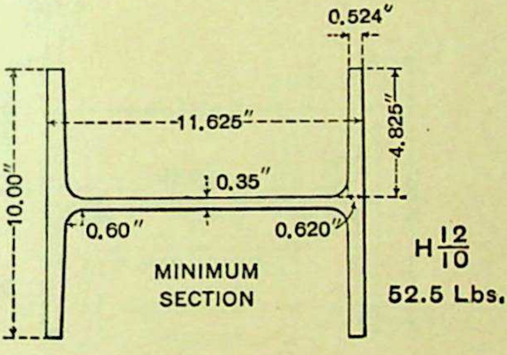
For increased weights and dimensions, see page 64.

BETHLEHEM COLUMNS.

SUPPLEMENTARY SECTIONS.



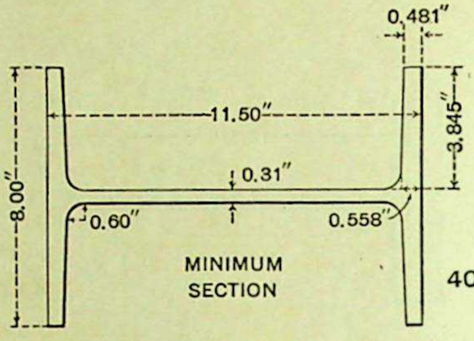
For increased weights and dimensions, see page 64.



For increased weights and dimensions, see page 64.

BETHLEHEM COLUMNS.

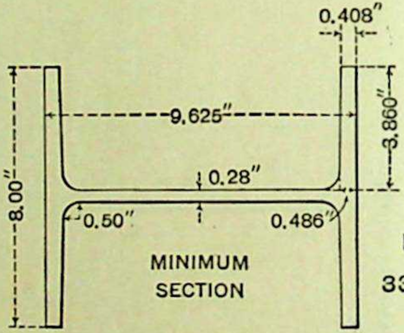
SUPPLEMENTARY SECTIONS.



$H\frac{12}{8}$

40.5 Lbs.

For increased weights and dimensions, see page 64.



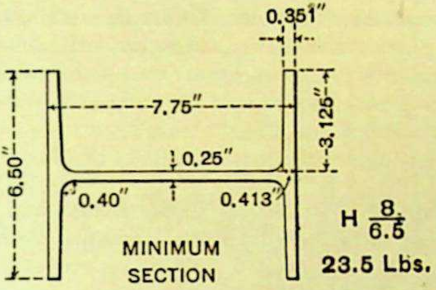
$H\frac{10}{8}$

33.5 Lbs.

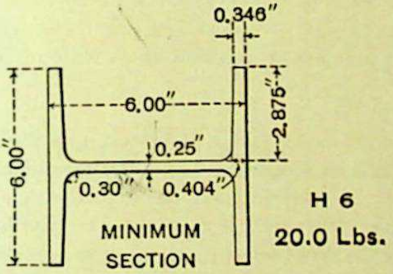
For increased weights and dimensions, see page 66.

BETHLEHEM COLUMNS.

SUPPLEMENTARY SECTIONS.



For increased weights and dimensions, see page 66.



For increased weights and dimensions, see page 66.

EXPLANATION OF TABLES OF
DIMENSIONS AND PROPERTIES OF BETHLEHEM STRUCTURAL SHAPES.

Dimensions of Bethlehem Girder Beams and I Beams. Prints of the profiles of the sections together with tables of weights and dimensions of Bethlehem Girder Beams and Bethlehem I Beams are shown on pages 9 to 25. The present list of Bethlehem Girder Beams and I Beams, given herein, provides a variety of sections sufficient to meet the requirements of building construction.

Properties of Bethlehem Girder Beams and I Beams. The properties of Bethlehem Girder Beams and Bethlehem I Beams with certain identifying dimensions are given on pages 40 to 47. Fillets are considered only in the computation of the weights, the computation of areas and all other properties being made for sections composed of their straight lines extended to meet at angles.

The Moment of Inertia of a plane section about an axis is the sum of the products of the differential areas into the squares of their distances from the axis.

The Moment of Inertia of the cross section of a member is an expression related to the stiffness and strength of the member and is an important function from which other properties are derived.

The Radius of Gyration of a section is the distance from the Neutral Axis to a point at which the area of the section may be considered as concentrated in determining the Moment of Inertia about this axis. It is obtained by dividing the Moment of Inertia by the area and extracting the square root of the quotient.

The Radius of Gyration is used in making calculations relating to the carrying capacity of columns.

The Section Modulus is a measure of the strength of a section used as a beam subject to flexure. It is obtained by dividing the

Moment of Inertia by the distance of the extreme fiber from the Neutral Axis.

Moments of Inertia, Radii of Gyration, and Section Moduli are given in the tables for the major and minor axes X-X and Y-Y respectively.

Coefficients of Strength, C, C′, and C″, are given in the tables for maximum fiber stresses of 18,000, 16,000, and 12,000 pounds per square inch, respectively.

The Coefficients of Strength are the safe loads, in pounds, uniformly distributed, including its own weight, for a member one foot long used as a beam. In accordance with the theory of flexure, the strength of any particular rolled beam varies inversely with its length, so that the safe load for any span may be obtained by dividing its Coefficient of Strength by the length of the span, in feet.

This may be explained as follows:—

NOTATION.

W = Total load, uniformly distributed, including weight of beam, pounds.

l = Length of span, inches.

f = Stress in extreme fiber, pounds per square inch.

S = Section Modulus, obtained by dividing the Moment of Inertia by the distance of the extreme fiber from the Neutral Axis, inches.^{3}

From the theory of flexure, the Bending Moment due to a uniformly distributed load is

$$\frac{Wl}{8} \text{ inch pounds, and } \frac{Wl}{8} = fS.$$

For a beam 1 foot, or 12 inches, long:—

$$\frac{W \times 12}{8} = fS, \quad \text{hence:—} \qquad W = \frac{2}{3} fS,$$

and, if the unit stresses are 18,000, 16,000, and 12,000 pounds per square inch, the Coefficients of Strength are as follows:—

$$C = \tfrac{2}{3} \times 18{,}000 \times S$$

$$C' = \tfrac{2}{3} \times 16{,}000 \times S$$

$$C'' = \tfrac{2}{3} \times 12{,}000 \times S$$

Many building codes still limit the extreme fiber stress in bending to 16,000 pounds per square inch, but recent practice in building design tends toward the use of 18,000 pounds per square inch, when the loads are quiescent or nearly so. Where moving loads are to be supported, a fiber stress of 12,000 pounds per square inch is ordinarily used.

Still smaller unit stresses should be used where loads are applied suddenly, because, under impact, the stress produced may be as much as double the stress due to the same load in a quiescent state. The Coefficients of Strength for any given beam are proportional to the respective fiber stresses, so that a coefficient for any other fiber stress can be found by direct proportion.

To select a beam to support a given load for a given span:—Find the required Coefficient of Strength by multiplying the uniformly distributed load, in pounds, by the span, in feet; then refer to the tables for a section having a coefficient of that value.

For example:—What is the proper size of beam for supporting a uniformly distributed load of 28,000 pounds, including its own weight, for a span of 25 feet, using a fiber stress of 18 000 pounds per square inch?

The coefficient required is found thus:—

$$C = 28{,}000 \times 25 = 700{,}000$$

Referring to the tables on pages 46 and 47, a 15-inch beam, section number B15, weighing 38.5 pounds per foot, has a Coefficient of Strength of 707,900 and is the proper beam for the purpose.

If the load is concentrated at the center of the span, the safe load is one-half the safe uniformly distributed load for the same span. To select a beam for supporting a load concentrated at the center of the span, multiply the given load by 2, and the figure thus obtained can now be used as a uniformly distributed load in referring to the tables to find the proper beam.

If the load is not uniformly distributed, or not concentrated at the center of span, the Bending Moment must be employed. The maximum Bending Moment caused by all the loads or forces must be obtained by figuring according to the principles of mechanics. The Moment of Resistance of the beam, in foot pounds, must not be less than the greatest Bending Moment of the loading or forces, in foot pounds. Moments of Resistance, in foot pounds, for Bethlehem Girder Beams and I Beams are given on pages 48 to 51, inclusive, by the use of which, beam sections having the proper strength can be selected as just described.

In selecting the proper beam required to support a given loading, the Section Modulus may also be used. The Section Modulus required is found by dividing the maximum Bending Moment of the loading, in inch pounds, by the allowable fiber stress, in pounds per square inch.

The maximum fiber stress, in pounds per square inch, in a beam supporting a given loading, is found by dividing the maximum Bending Moment produced by the loading, in inch pounds by the Section Modulus of the beam.

Formulas and diagrams for the Bending Moments and other data for beams subjected to the more usual cases of loading occurring in ordinary practice are given on pages 166 to 169.

On pages 52 to 55 are given Tables of Comparison of Bethlehem Girder Beams and Bethlehem I Beams with Standard I beams and girders of equivalent strengths.

In the case of very short spans, or of heavy concentrated loads, the crippling strength of the web of the beam or girder may limit the safe allowable load, or determine the selection of a section for supporting a given loading. The tables on pages 40 to 47 give the maximum safe shear on the webs calculated by the formula explained on page 94 for a maximum unit shear of 12,000 pounds per square inch.

Dimensions and Properties of Bethlehem Columns. The tables on pages 56 to 69, inclusive, give the dimensions, weights, areas and structural properties of Bethlehem Columns for all the various sizes rolled. Similar information with regard to Reinforced 14-inch H Columns and Special Compound Columns is tabulated on pages 70 to 73, inclusive.

The dimension T, in the tables, is the nominal average thickness of the flange, and is stated in even fractions of an inch.

The clear distance between the flange fillets is denoted by the dimension L, given in the tables, and is the depth of the flat surface of the web available for connections.

All columns having the same section number are obtained from the same set of rolls. Thus, all the sizes of 14-inch H Columns tabulated on page 56 are produced by the same rolls; the variation in dimensions of the series of sections being formed by the proportionate separation of the horizontal and vertical rolls.

In selecting columns it is advisable, wherever possible, to secure the desired range of sizes, from minimum to maximum, by confining the selection to columns having the same section number, as all the columns can then be secured from the same rolling, thereby avoiding delay in delivery.

The Moment of Inertia, Section Modulus, and Radius of Gyration are given with reference to both axes for all columns. The Section Moduli may be used to determine the transverse strength in case it is desired to use the column sections as beams. The Coefficient of Strength for such purpose may be obtained in the following manner:—

$$C = \tfrac{2}{3} fS$$

where,

f = Allowable fiber stress, in pounds per square inch.

S = Section Modulus, in inches.^{3}

C = Coefficient of Strength, in foot pounds.

The Radius of Gyration, r, is used in calculating the carrying capacity of columns. The ratio of the unsupported length, l, of the column to the Radius of Gyration, r, is a measure of the tendency of the column to deflect. This ratio is called the "l over r" or "ratio of slenderness" of the column and enters into every formula for long columns.

Bending Factors. To aid in the selection of columns subjected to direct loads, and also to bending produced by eccentric loads or by other means, Bending Factors are given in the column tables which furnish a convenient and practical method of converting the Bending Moment into an equivalent direct central load.

NOTATION.

P' = Centrally applied load, in pounds.
P'' = Eccentric load, in pounds.
M = Bending Moment, in inch pounds, produced by P''.
P''' = An equivalent central load, in pounds, producing the same maximum stress as the Bending Moment.
P = Total equivalent load on column, in pounds.
f = Fiber stress, in pounds per square inch, due to bending.
S = Section Modulus about axis of bending, in inches.^{3}
A = Area of section, in square inches.
k = Bending Factor $= A \div S$.

Then, $f = \frac{M}{S}$, and, by assumption, $\frac{P'''}{A} = f$.

But as $k = \frac{A}{S}$, then $f = \frac{Mk}{A} = \frac{P'''}{A}$, and $P''' = Mk$.

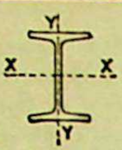
Therefore, $P = P' + P'' + P''' = P' + P'' + Mk$.

Hence, if the Bending Moment, in inch pounds, is multiplied by the Bending Factor, k, the product is an equivalent central load on the column producing the same compressive stress as the Bending Moment.

A further explanation and an example relating to Bending Factors are given on pages 97 to 100.

The Supplementary Sections of Bethlehem Columns will be found particularly well adapted to resist combined direct and bending stresses.

For Bethlehem Girder Beams and Bethlehem I Beams used as columns, and also carrying an eccentric load, Bending Factors are given in the Tables of Safe Loads on pages 102 to 109, inclusive.



PROPERTIES OF

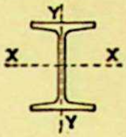
BETHLEHEM GIRDER BEAMS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area of Section, Square Inches.	Thickness of Web, Inches.	Width of Flange, Inches.	AXIS X-X.		
						Moment of Inertia Inches.^{4} I	Radius of Gyration, Inches. r	Section Modulus, Inches.^{3} S
G30	30⅛	200.0	58.52	.76	15.04	9148.8	12.50	607.5
	30	190.0	55.52	.72	15.00	8651.1	12.48	576.7
	29⅞	181.0	52.82	.69	14.97	8181.0	12.45	547.6
G28	28⅛	175.0	51.02	.70	14.29	6988.7	11.70	497.1
	28	165.0	48.19	.66	14.25	6577.9	11.68	469.9
G26	26⅛	160.0	46.85	.67	13.79	5576.6	10.91	427.0
	26	151.0	44.16	.63	13.75	5237.1	10.89	402.9
	25⅞	144.0	41.99	.61	13.73	4930.6	10.84	381.0
G24a	24⅛	149.0	43.57	.65	13.29	4451.1	10.11	369.1
	24	141.0	41.02	.61	13.25	4174.2	10.09	347.9
	23⅞	133.0	38.71	.58	13.22	3912.4	10.05	327.7
G24	24⅛	129.0	37.74	.58	12.29	3844.8	10.09	318.8
	24	121.0	35.30	.54	12.25	3585.3	10.08	298.8
	23⅞	114.0	33.12	.51	12.22	3340.6	10.04	279.8
G20a	20⅛	149.0	43.44	.69	12.78	3106.6	8.46	308.8
	20	142.0	41.31	.66	12.75	2932.3	8.43	293.2
	19⅞	135.0	39.18	.63	12.72	2760.6	8.39	277.7
G20	20⅛	120.0	34.95	.59	12.03	2505.5	8.47	249.1
	20	113.0	32.90	.56	12.00	2340.2	8.43	234.0
	19⅞	107.0	31.06	.54	11.98	2184.0	8.39	219.7
G18	18⅛	100.0	29.25	.52	11.54	1725.7	7.68	190.5
	18	93.0	27.14	.48	11.50	1593.4	7.66	177.0
	17⅞	87.5	25.40	.46	11.48	1472.8	7.61	164.7

W =Safe Load, in pounds, uniformly distributed, including weight of beam.
L =Span, in feet.
M_f= Bending Moment of forces, in foot pounds.
f =Allowable Fiber Stress, in pounds per square inch.
S =Section Modulus about axis X-X.

PROPERTIES OF

BETHLEHEM GIRDER BEAMS.

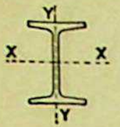


COEFFICIENTS OF STRENGTH.				AXIS Y-Y.			
For Fiber Stress of 18,000 Lbs. per Sq. In. For Quiescent Loads. C	For Fiber Stress of 16,000 Lbs. per Sq. In. For Quiescent Loads. C′	For Fiber Stress of 12,000 Lbs. per Sq. In. For Moving Loads. C″	Maximum Safe Shear on Web, in Pounds.	Moment of Inertia, Inches.⁴ I′	Radius of Gyration, Inches. r′	Section Modulus, Inches.³ S′	Section Number.
7,290,000	6,480,000	4,860,000	217,400	628.5	3.28	83.6	G30
6,921,000	6,152,000	4,614,000	198,400	589.4	3.26	78.6	
6,571,000	5,841,000	4,381,000	184,200	552.0	3.23	73.7	
5,965,000	5,302,000	3,976,000	185,300	496.2	3.12	69.4	G28
5,638,000	5,012,000	3,759,000	167,700	462.8	3.10	65.0	
5,124,000	4,555,000	3,416,000	168,200	432.8	3.04	62.8	G26
4,834,000	4,297,000	3,223,000	151,700	402.7	3.02	58.6	
4,572,000	4,064,000	3,048,000	143,200	375.0	2.99	54.6	
4,429,000	3,937,000	2,953,000	155,500	383.3	2.97	57.7	G24a
4,174,000	3,710,000	2,783,000	140,200	356.4	2.95	53.8	
3,932,000	3,495,000	2,621,000	128,700	330.7	2.92	50.0	
3,826,000	3,401,000	2,550,000	129,100	278.2	2.72	45.3	G24
3,585,000	3,187,000	2,390,000	114,100	256.9	2.70	41.9	
3,357,000	2,984,000	2,238,000	102,900	236.7	2.67	38.7	
3,706,000	3,294,000	2,470,000	155,400	384.5	2.97	60.2	G20a
3,519,000	3,128,000	2,346,000	145,400	360.9	2.96	56.6	
3,333,000	2,962,000	2,222,000	135,500	337.6	2.94	53.1	
2,989,000	2,657,000	1,992,000	123,500	260.1	2.73	43.2	G20
2,808,000	2,496,000	1,872,000	113,700	240.8	2.71	40.1	
2,637,000	2,344,000	1,758,000	106,900	222.3	2.68	37.1	
2,286,000	2,032,000	1,524,000	97,100	202.6	2.63	35.1	G18
2,125,000	1,888,000	1,416,000	85,500	185.1	2.61	32.2	
1,977,000	1,757,000	1,318,000	79,500	168.9	2.58	29.4	

C, C′, and C″ = Coefficients given in the table.

$W = \frac{C}{L}$, or $\frac{C'}{L}$, or $\frac{C''}{L}$; $M_t = \frac{C}{8}$, or $\frac{C'}{8}$, or $\frac{C''}{8}$

C, or C′, or $C'' = WL = 8M_t = \frac{2}{3} f S$



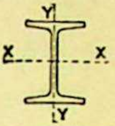
PROPERTIES OF

BETHLEHEM GIRDER BEAMS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area of Section, Square Inches.	Thickness of Web, Inches.	Width of Flange, Inches.	AXIS X-X.		
						Moment of Inertia, Inches.^{4} I	Radius of Gyration, Inches. r	Section Modulus, Inches.^{3} S
	15⅛	147.0	42.73	.83	11.78	1666.2	6.24	220.4
G15b	15	141.0	40.86	.80	11.75	1577.7	6.21	210.4
	14⅞	135.0	39.01	.77	11.72	1490.7	6.18	200.4
	15⅛	111.0	32.40	.64	11.29	1306.3	6.35	172.8
G15a	15	105.0	30.45	.60	11.25	1218.2	6.32	162.4
	14⅞	99.0	28.65	.57	11.22	1134.7	6.29	152.5
	15⅛	80.5	23.44	.48	10.79	968.5	6.43	128.1
G15	15	74.0	21.55	.44	10.75	883.8	6.40	117.8
	14⅞	69.0	19.96	.42	10.73	806.4	6.36	108.4
	12⅛	76.5	22.29	.51	10.29	589.0	5.14	97.2
G12a	12	70.5	20.57	.47	10.25	538.4	5.12	89.7
	11⅞	66.0	19.11	.45	10.23	491.7	5.07	82.8
	12⅛	61.0	17.77	.41	10.03	479.9	5.20	79.2
G12	12	55.5	16.21	.38	10.00	431.8	5.16	72.0
	11 29/32	51.5	15.07	.36	9.98	396.9	5.13	66.6
	10⅛	50.0	14.51	.36	9.04	275.5	4.36	54.4
G10	10	44.5	13.03	.32	9.00	244.7	4.33	48.9
	9 29/32	41.5	12.12	.31	8.99	223.8	4.30	45.2
	9⅛	43.5	12.62	.35	8.54	193.8	3.92	42.5
G9	9	38.5	11.23	.31	8.50	170.3	3.89	37.9
	8 15/16	36.0	10.55	.29	8.48	158.9	3.88	35.5
	8⅛	37.0	10.77	.33	8.03	131.1	3.49	32.3
G8	8	33.0	9.57	.30	8.00	114.2	3.45	28.6
	7 15/16	31.0	9.01	.29	7.99	106.2	3.43	26.7

W =Safe Load, in pounds, uniformly distributed, including weight of beam.
L =Span, in feet.
M_f =Bending Moment of forces, in foot pounds.
f =Allowable Fiber Stress, in pounds per square inch.
S =Section Modulus about axis X-X.

PROPERTIES OF
BETHLEHEM GIRDER BEAMS.

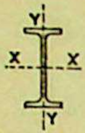


COEFFICIENTS OF STRENGTH.				AXIS Y-Y.			
For Fiber Stress of 18,000 Lbs. per Sq. In. For Quiescent Loads.	For Fiber Stress of 16,000 Lbs. per Sq. In. For Quiescent Loads.	For Fiber Stress of 12,000 Lbs. per Sq. In. For Moving Loads.	Maximum Safe Shear on Web, in Pounds.	Moment of Inertia, Inches.^{4}	Radius of Gyration, Inches.	Section Modulus, Inches.^{3}	Section Number.
C	C′	C″		I′	r′	S′	
2,645,000	2,351,000	1,763,000	150,600	347.3	2.85	59.0	G15b
2,524,000	2,244,000	1,683,000	144,000	328.3	2.83	55.9	
2,404,000	2,137,000	1,603,000	137,500	309.5	2.82	52.8	
2,074,000	1,843,000	1,382,000	115,800	231.2	2.67	41.0	G15a
1,949,000	1,733,000	1,299,000	106,100	214.3	2.65	38.1	
1,830,000	1,627,000	1,220,000	98,600	198.4	2.63	35.4	
1,537,000	1,367,000	1,025,000	78,400	143.0	2.47	26.5	G15
1,414,000	1,257,000	942,800	68,700	128.9	2.45	24.0	
1,301,000	1,156,000	867,100	63,700	115.8	2.41	21.6	
1,166,000	1,037,000	777,600	73,900	132.1	2.43	25.7	G12a
1,077,000	957,100	717,800	66,000	119.7	2.41	23.4	
993,400	883,000	662,300	61,900	108.3	2.38	21.2	
950,300	844,700	633,500	55,300	95.8	2.32	19.1	G12
863,600	767,700	575,800	49,300	84.9	2.29	17.0	
799,700	710,800	533,100	45,300	76.9	2.26	15.4	
653,300	580,800	435,600	41,500	66.4	2.14	14.7	G10
587,300	522,100	391,500	35,000	58.2	2.11	12.9	
542,100	481,900	361,400	33,200	52.6	2.08	11.7	
510,000	453,400	340,000	37,200	51.3	2.02	12.0	G9
454,300	403,800	302,800	31,300	44.4	1.99	10.4	
426,600	379,200	284,400	28,400	41.0	1.97	9.67	
387,600	344,500	258,400	31,700	38.7	1.90	9.65	G8
342,600	304,500	228,400	27,700	33.2	1.86	8.29	
320,900	285,200	213,900	26,300	30.5	1.84	7.63	

C, C′, and C″ = Coefficients given in the table.

$W=\frac{C}{L}$, or $\frac{C'}{L}$, or $\frac{C''}{L}$; $M_f=\frac{C}{8}$, or $\frac{C'}{8}$, or $\frac{C''}{8}$

C, or C', or $C'' = WL = 8M_f = \frac{2}{3} f S$



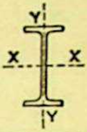
PROPERTIES OF
BETHLEHEM I BEAMS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area of Section, Square Inches.	Thickness of Web, Inches.	Width of Flange, Inches.	AXIS X-X.		
						Moment of Inertia, Inches.^{4} I	Radius of Gyration, Inches. r	Section Modulus, Inches.^{3} S
B30	30⅛	129.0	37.52	.580	10.530	5566.5	12.18	369.6
	30	121.0	35.36	.550	10.500	5213.6	12.14	347.6
	29⅞	115.0	33.50	.530	10.480	4886.8	12.08	327.1
B28	28⅛	113.0	32.98	.540	10.030	4285.5	11.40	304.8
	28	106.0	30.93	.510	10.000	3993.8	11.36	285.3
	27⅞	100.0	29.18	.490	9.980	3723.4	11.30	267.1
B26	26⅛	98.0	28.47	.500	9.530	3200.9	10.60	245.1
	26	91.0	26.55	.470	9.500	2962.8	10.56	227.9
	25⅞	85.5	24.89	.450	9.480	2742.2	10.50	211.9
B24b	24 3/32	104.5	30.63	.550	9.775	2967.7	9.84	246.4
	24	99.5	29.15	.525	9.750	2811.7	9.82	234.3
	23 29/32	95.5	27.79	.505	9.730	2663.1	9.79	222.8
B24a	24	84.5	24.75	.460	9.500	2380.1	9.81	198.3
B24	24 3/32	79.5	23.17	.430	9.035	2245.3	9.84	186.4
	24	73.5	21.52	.395	9.000	2087.4	9.85	173.9
B22	22⅛	71.5	20.88	.420	8.535	1705.2	9.04	154.2
	22 1/16	68.5	20.04	.405	8.520	1629.3	9.02	147.7
	22	65.5	19.08	.385	8.500	1549.5	9.01	140.9
B20a	20 3/32	78.0	22.77	.460	8.905	1568.3	8.30	156.1
	20	73.0	21.37	.430	8.875	1467.8	8.29	146.8
B20	20⅛	64.5	18.79	.400	8.025	1283.2	8.26	127.6
	20 1/16	62.0	18.11	.390	8.015	1227.9	8.23	122.4
	20	59.5	17.33	.375	8.000	1169.7	8.22	117.0

W =Safe Load in pounds, uniformly distributed, including weight of beam.
L =Span, in feet.
M_f =Bending Moment of forces, in foot pounds.
f =Allowable Fiber Stress, in pounds per square inch.
S =Section Modulus about axis X-X.

PROPERTIES OF

BETHLEHEM I BEAMS.

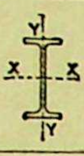


COEFFICIENTS OF STRENGTH.				AXIS Y-Y.			
For Fiber Stress of 18,000 Lbs. per Sq. In. For Quiescent Loads. C	For Fiber Stress of 16,000 Lbs. per Sq. In. For Quiescent Loads. C′	For Fiber Stress of 12,000 Lbs. per Sq. In. For Moving Loads. C″	Maximum Safe Shear on Web, in Pounds.	Moment of Inertia, Inches.^{4} I′	Radius of Gyration, Inches. r′	Section Modulus, Inches.^{3} S′	Section Number.
4,435,000	3,943,000	2,957,000	134,000	177.5	2.18	33.7	
4,171,000	3,707,000	2,781,000	120,700	164.3	2.16	31.3	B30
3,925,000	3,489,000	2,617,000	111,900	151.8	2.13	29.0	
3,658,000	3,251,000	2,438,000	116,200	142.3	2.08	28.4	
3,423,000	3,043,000	2,282,000	103,800	130.9	2.06	26.2	B28
3,205,000	2,849,000	2,137,000	95,700	120.2	2.03	24.1	
2,941,000	2,614,000	1,961,000	99,600	110.6	1.97	23.2	
2,735,000	2,431,000	1,823,000	88,100	100.9	1.95	21.2	B26
2,543,000	2,260,000	1,695,000	80,600	91.6	1.92	19.3	
2,957,000	2,628,000	1,971,000	117,300	132.9	2.08	27.2	
2,812,000	2,499,000	1,874,000	107,900	124.8	2.07	25.6	B24b
2,673,000	2,376,000	1,782,000	100,500	117.1	2.05	24.1	
2,380,000	2,116,000	1,587,000	84,200	95.8	1.97	20.2	B24a
2,237,000	1,988,000	1,491,000	73,900	81.2	1.87	18.0	B24
2,087,000	1,855,000	1,392,000	62,200	74.7	1.86	16.6	
1,850,000	1,645,000	1,233,000	70,300	65.8	1.78	15.4	
1,773,000	1,576,000	1,182,000	65,500	62.3	1.76	14.6	B22
1,690,000	1,503,000	1,127,000	59,200	58.8	1.76	13.8	
1,874,000	1,665,000	1,249,000	82,200	84.6	1.93	19.0	B20a
1,761,000	1,566,000	1,174,000	72,900	78.5	1.92	17.7	
1,531,000	1,361,000	1,020,000	63,700	54.3	1.70	13.5	
1,469,000	1,306,000	979,400	60,700	51.5	1.69	12.9	B20
1,404,000	1,248,000	935,700	56,200	48.6	1.68	12.2	

C, C′, and C″ = Coefficients given in the table.

$W=\frac{C}{L}$, or $\frac{C'}{L}$, or $\frac{C''}{L}$; $M_f=\frac{C}{8}$, or $\frac{C'}{8}$, or $\frac{C''}{8}$

C, or C′, or $C''=WL=8M_f=\frac{2}{3}fS$



PROPERTIES OF

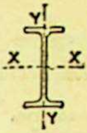
BETHLEHEM I BEAMS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area of Section, Square Inches.	Thickness of Web, Inches.	Width of Flange, Inches.	AXIS X-X.		
						Moment of Inertia, Inches.[4]	Radius of Gyration, Inches.	Section Modulus, Inches.[3]
						I	r	S
B18a	18⅛	74.0	21.61	.440	8.770	1238.0	7.57	136.6
	18	69.0	20.20	.420	8.750	1142.5	7.52	126.9
	17⅞	64.5	18.79	.400	8.730	1048.5	7.47	117.3
B18	18⅛	54.5	15.95	.370	7.540	888.5	7.46	98.1
	18$\frac{1}{16}$	52.0	15.22	.355	7.525	844.1	7.45	93.5
	18	49.0	14.32	.330	7.500	795.3	7.45	88.4
B15b	15	71.5	20.79	.520	7.500	789.4	6.16	105.3
B15a	15⅛	59.5	17.32	.450	7.040	668.7	6.21	88.4
	15	54.5	15.87	.410	7.000	609.5	6.20	81.3
	14⅞	50.5	14.66	.385	6.975	555.8	6.16	74.7
B15	15$\frac{3}{32}$	42.5	12.39	.325	6.785	486.8	6.27	64.5
	15$\frac{1}{32}$	40.0	11.68	.305	6.765	458.1	6.26	61.0
	15	38.5	11.26	.290	6.750	442.4	6.27	59.0
B12a	12	36.5	10.60	.310	6.380	269.2	5.04	44.9
B12	12$\frac{1}{16}$	31.0	9.02	.270	6.270	232.3	5.08	38.5
	12	28.5	8.40	.250	6.250	215.8	5.07	36.0
B10	10$\frac{3}{32}$	26.0	7.61	.270	5.770	136.7	4.24	27.1
	10	23.5	6.89	.250	5.750	121.9	4.21	24.4
B9	9$\frac{1}{16}$	22.0	6.45	.260	5.510	92.9	3.80	20.5
	9	20.5	6.02	.250	5.500	85.5	3.77	19.0
B8	8$\frac{1}{16}$	19.0	5.62	.270	5.270	62.9	3.35	15.6
	8	17.5	5.14	.250	5.250	56.9	3.33	14.2

W = Safe Load in pounds, uniformly distributed, including weight of beam.
L = Span, in feet.
M_f = Bending Moment of forces, in foot pounds.
f = Allowable Fiber Stress, in pounds per square inch.
S = Section Modulus about axis X-X.

PROPERTIES OF

BETHLEHEM I BEAMS.

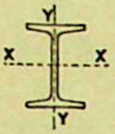


COEFFICIENTS OF STRENGTH.				AXIS Y-Y.			
For Fiber Stress of 18,000 Lbs. per Sq. In. For Quiescent Loads. C	For Fiber Stress of 16,000 Lbs. per Sq. In. For Quiescent Loads. C′	For Fiber Stress of 12,000 Lbs. per Sq. In. For Moving Loads. C″	Maximum Safe Shear on Web, in Pounds.	Moment of Inertia, Inches.⁴ I′	Radius of Gyration, Inches. r′	Section Modulus, Inches.³ S′	Section Number.
1,640,000	1,458,000	1,093,000	74,300	82.9	1.96	18.9	B18a
1,523,000	1,354,000	1,016,000	68,400	75.6	1.93	17.3	
1,407,000	1,251,000	938,200	62,600	68.4	1.91	15.7	
1,177,000	1,046,000	784,500	54,300	41.1	1.60	10.9	B18
1,122,000	997,100	747,800	50,200	38.7	1.59	10.3	
1,060,000	942,500	706,900	43,700	36.1	1.59	9.64	
1,263,000	1,123,000	842,000	87,500	60.8	1.71	16.2	B15b
1,061,000	943,400	707,600	71,300	42.8	1.57	12.1	B15a
975,200	866,900	650,100	61,600	38.6	1.56	11.0	
896,400	796,800	597,600	55,400	34.7	1.54	9.96	
774,300	688,300	516,200	41,700	26.9	1.47	7.92	B15
731,500	650,200	487,700	37,100	25.1	1.47	7.41	
707,900	629,200	471,900	33,800	24.1	1.46	7.15	
538,500	478,600	359,000	36,100	21.9	1.44	6.88	B12a
462,300	411,000	308,200	28,600	17.3	1.38	5.51	B12
431,700	383,700	287,800	24,900	15.9	1.38	5.08	
325,100	289,000	216,800	26,900	12.5	1.28	4.33	B10
292,600	260,100	195,100	23,600	10.9	1.26	3.80	
246,000	218,600	164,000	24,100	9.42	1.21	3.42	B9
228,000	202,700	152,000	22,600	8.53	1.19	3.10	
187,200	166,400	124,800	23,800	7.20	1.13	2.73	B8
170,800	151,800	113,900	21,200	6.39	1.11	2.43	

C, C′, and C″ = Coefficients given in the table.

$W = \frac{C}{L}$, or $\frac{C'}{L}$, or $\frac{C''}{L}$; $M_f = \frac{C}{8}$, or $\frac{C'}{8}$, or $\frac{C''}{8}$

C, or C′, or $C'' = WL = 8M_f = \frac{2}{3} f S$



MOMENTS OF RESISTANCE OF
BETHLEHEM GIRDER BEAMS
ABOUT AXIS X-X, IN FOOT POUNDS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	MOMENTS OF RESISTANCE, IN FOOT POUNDS.			
				For Fiber Stress of 18,000 Lbs. per Square Inch. R	For Fiber Stress of 16,000 Lbs. per Square Inch. R′	For Fiber Stress of 12,000 Lbs. per Square Inch. R″	For Fiber Stress of 10,000 Lbs. per Square Inch. R‴
G30	30⅛	200.0	217,400	911,200	810,000	607,500	506,200
	30	190.0	198,400	865,100	769,000	576,700	480,600
	29⅞	181.0	184,200	821,400	730,100	547,600	456,300
G28	28⅛	175.0	185,300	745,600	662,700	497,100	414,200
	28	165.0	167,700	704,800	626,500	469,900	391,500
G26	26⅛	160.0	168,200	640,500	569,300	427,000	355,800
	26	151.0	151,700	604,300	537,100	402,900	335,700
	25⅞	144.0	143,200	571,600	508,100	381,000	317,500
G24a	24⅛	149.0	155,500	553,600	492,100	369,100	307,600
	24	141.0	140,200	521,800	463,800	347,900	289,900
	23⅞	133.0	128,700	491,500	436,900	327,700	273,100
G24	24⅛	129.0	129,100	478,200	425,100	318,800	265,700
	24	121.0	114,100	448,200	398,400	298,800	249,000
	23⅞	114.0	102,900	419,700	373,000	279,800	233,200
G20a	20⅛	149.0	155,400	463,200	411,700	308,800	257,300
	20	142.0	145,400	439,800	391,000	293,200	244,400
	19⅞	135.0	135,500	416,600	370,300	277,700	231,400
G20	20⅛	120.0	123,500	373,600	332,100	249,100	207,500
	20	113.0	113,700	351,000	312,000	234,000	195,000
	19⅞	107.0	106,900	329,600	293,000	219,700	183,100
G18	18⅛	100.0	97,100	285,700	254,000	190,500	158,700
	18	93.0	85,500	265,600	236,100	177,000	147,500
	17⅞	87.5	79,500	247,100	219,700	164,700	137,300

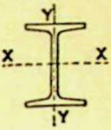
W = Total uniformly distributed load, in pounds, including weight of beam.
P = Single concentrated load, in pounds, at center of span.
L = Span, in feet.
M_l = Bending Moment of forces, in foot pounds.

MOMENTS OF RESISTANCE OF

BETHLEHEM GIRDER BEAMS

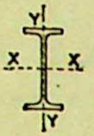
ABOUT AXIS X-X,

IN FOOT POUNDS.



Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	MOMENTS OF RESISTANCE, IN FOOT POUNDS.			
				For Fiber Stress of 18,000 Lbs. per Square Inch. R	For Fiber Stress of 16,000 Lbs. per Square Inch. R′	For Fiber Stress of 12,000 Lbs. per Square Inch. R″	For Fiber Stress of 10,000 Lbs. per Square Inch. R‴
G15b	$15\frac{1}{8}$	147.0	150,600	330,600	293,900	220,400	183,700
	15	141.0	144,000	315,500	280,500	210,400	175,300
	$14\frac{7}{8}$	135.0	137,500	300,600	267,200	200,400	167,000
G15a	$15\frac{1}{8}$	111.0	115,800	259,200	230,400	172,800	144,000
	15	105.0	106,100	243,600	216,600	162,400	135,400
	$14\frac{7}{8}$	99.0	98,600	228,800	203,300	152,500	127,100
G15	$15\frac{1}{8}$	80.5	78,400	192,200	170,800	128,100	106,800
	15	74.0	68,700	176,800	157,100	117,800	98,200
	$14\frac{7}{8}$	69.0	63,700	162,600	144,500	108,400	90,320
G12a	$12\frac{1}{8}$	76.5	73,900	145,800	129,600	97,200	81,000
	12	70.5	66,000	134,600	119,600	89,730	74,770
	$11\frac{7}{8}$	66.0	61,900	124,200	110,400	82,790	68,990
G12	$12\frac{1}{8}$	61.0	55,300	118,800	105,600	79,190	65,990
	12	55.5	49,300	108,000	95,960	71,970	59,980
	$11\frac{29}{32}$	51.5	45,300	99,960	88,860	66,640	55,530
G10	$10\frac{1}{8}$	50.0	41,500	81,670	72,590	54,450	45,370
	10	44.5	35,000	73,410	65,260	48,940	40,790
	$9\frac{29}{32}$	41.5	33,200	67,760	60,230	45,170	37,640
G9	$9\frac{1}{8}$	43.5	37,200	63,750	56,670	42,500	35,420
	9	38.5	31,300	56,780	50,470	37,860	31,550
	$8\frac{15}{16}$	36.0	28,400	53,320	47,400	35,550	29,620
G8	$8\frac{1}{8}$	37.0	31,700	48,450	43,060	32,300	26,920
	8	33.0	27,700	42,830	38,070	28,550	23,790
	$7\frac{15}{16}$	31.0	26,300	40,110	35,650	26,740	22,280

R, R′, R″ and R‴ = Moments of Resistance given in the table.
M_r = R, R′, R″ or R‴.
R, R′, R″ or R‴ = $\frac{1}{8}$ WL; R, R′, R″ or R‴ = $\frac{1}{4}$ PL + $\frac{1}{8}$ WL.



MOMENTS OF RESISTANCE OF

BETHLEHEM I BEAMS

ABOUT AXIS X-X, IN FOOT POUNDS.

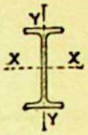
Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	MOMENTS OF RESISTANCE, IN FOOT POUNDS.			
				For Fiber Stress of 18,000 Lbs. per Square Inch. R	For Fiber Stress of 16,000 Lbs. per Square Inch. R′	For Fiber Stress of 12,000 Lbs. per Square Inch. R″	For Fiber Stress of 10,000 Lbs. per Square Inch. R‴
B30	$30\frac{1}{8}$	129.0	134,000	554,400	492,800	369,600	308,000
	30	121.0	120,700	521,400	463,400	347,600	289,600
	$29\frac{7}{8}$	115.0	111,900	490,600	436,100	327,100	272,600
B28	$28\frac{1}{8}$	113.0	116,200	457,200	406,400	304,800	254,000
	28	106.0	103,800	427,900	380,400	285,300	237,700
	$27\frac{7}{8}$	100.0	95,700	400,700	356,100	267,100	222,600
B26	$26\frac{1}{8}$	98.0	99,600	367,600	326,800	245,100	204,200
	26	91.0	88,100	341,900	303,900	227,900	189,900
	$25\frac{7}{8}$	85.5	80,600	317,900	282,600	211,900	176,600
B24b	$24\frac{3}{32}$	104.5	117,300	369,600	328,500	246,400	205,300
	24	99.5	107,900	351,500	312,400	234,300	195,300
	$23\frac{29}{32}$	95.5	100,500	334,100	297,000	222,800	185,600
B24a	24	84.5	84,200	297,500	264,500	198,300	165,300
B24	$24\frac{3}{32}$	79.5	73,900	279,600	248,500	186,400	155,300
	24	73.5	62,200	260,900	231,900	173,900	145,000
B22	$22\frac{1}{8}$	71.5	70,300	231,300	205,600	154,200	128,500
	$22\frac{1}{16}$	68.5	65,500	221,600	197,000	147,700	123,100
	22	65.5	59,200	211,300	187,800	140,900	117,400
B20a	$20\frac{3}{32}$	78.0	82,200	234,200	208,200	156,100	130,100
	20	73.0	72,900	220,200	195,700	146,800	122,300
B20	$20\frac{1}{8}$	64.5	63,700	191,300	170,100	127,600	106,300
	$20\frac{1}{16}$	62.0	60,700	183,600	163,200	122,400	102,000
	20	59.5	56,200	175,500	156,000	117,000	97,470

W = Total uniformly distributed load, in pounds, including weight of beam.
P = Single concentrated load, in pounds, at center of span.
L = Span, in feet.
M_f = Bending Moment of forces, in foot pounds.

MOMENTS OF RESISTANCE OF

BETHLEHEM I BEAMS

ABOUT AXIS X-X, IN FOOT POUNDS.



Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	MOMENTS OF RESISTANCE, IN FOOT POUNDS.			
				For Fiber Stress of 18,000 Lbs. per Square Inch. R	For Fiber Stress of 16,000 Lbs. per Square Inch. R′	For Fiber Stress of 12,000 Lbs. per Square Inch. R″	For Fiber Stress of 10,000 Lbs. per Square Inch. R‴
B18a	18 1/8	74.0	74,300	205,000	182,200	136,600	113,900
	18	69.0	68,400	190,400	169,300	126,900	105,800
	17 7/8	64.5	62,600	175,900	156,400	117,300	97,730
B18	18 1/8	54.5	54,300	147,100	130,800	98,070	81,720
	18 1/16	52.0	50,200	140,200	124,600	93,480	77,900
	18	49.0	43,700	132,500	117,800	88,360	73,640
B15b	15	71.5	87,500	157,900	140,300	105,300	87,710
B15a	15 1/8	59.5	71,300	132,700	117,900	88,450	73,710
	15	54.5	61,600	121,900	108,400	81,270	67,720
	14 7/8	50.5	55,400	112,100	99,600	74,700	62,250
B15	15 3/32	42.5	41,700	96,790	86,030	64,520	53,770
	15 1/32	40.0	37,100	91,440	81,280	60,960	50,800
	15	38.5	33,800	88,490	78,660	58,990	49,160
B12a	12	36.5	36,100	67,310	59,830	44,870	37,390
B12	12 1/16	31.0	28,600	57,790	51,370	38,530	32,110
	12	28.5	24,900	53,960	47,960	35,970	29,980
B10	10 3/32	26.0	26,900	40,640	36,130	27,100	22,580
	10	23.5	23,600	36,580	32,510	24,390	20,320
B9	9 1/16	22.0	24,100	30,750	27,330	20,500	17,080
	9	20.5	22,600	28,500	25,340	19,000	15,840
B8	8 1/16	19.0	23,800	23,410	20,810	15,600	13,000
	8	17.5	21,200	21,350	18,980	14,230	11,860

R, R,′ R″ and R‴ = Moments of Resistance given in the table.
M_f = R, R′, R″ or R.‴
R, R′, R″ or R‴ = ⅛ WL; R, R′, R″ or R‴ = ¼ PL + ⅛ WL.

COMPARISON OF

BETHLEHEM GIRDER BEAMS

WITH GIRDERS OF TWO AMERICAN STANDARD I BEAMS.

BETHLEHEM GIRDER BEAMS.				GIRDERS COMPOSED OF TWO STANDARD BEAMS.			Weight Saved by Bethlehem Beams, in Pounds per Foot.
Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Section Modulus, Inches.^{3}	Depth of Beams, Inches.	Weight of each Beam, per Foot, Pounds.	Section Modulus of two Beams, Inches.^{3}	
G30	30⅛	200.0	607.5	. .	NOTE:—The Section Modulus of the Standard Girder marked (a) exceeds that of the Bethlehem Girder Beam. The Section Modulus of the Standard Girder marked (b) is less than that of the Bethlehem Girder Beam.		
	30	190.0	576.7	. .			
	29⅞	181.0	547.6	. .			
G28	28⅛	175.0	497.1	. .			
	28	165.0	469.9	. .			
G26	26⅛	160.0	427.0	. .			
	26	151.0	402.9	. .			
	25⅞	144.0	381.0	. .			
G24a	24⅛	149.0	369.1	24 24	(a) 90.0 (b) 85.0	371.6 360.0	31.0 21.0
	24	141.0	347.9	24	79.9	347.8	18.8
	23⅞	133.0	327.7	. .	. .	. .	. .
G24	24⅛	129.0	318.8	. .	. .	. .	. .
	24	121.0	298.8	. .	. .	. .	. .
	23⅞	114.0	279.8	. .	. .	. .	. .
G20a	20⅛	149.0	308.8	20 20	(a) 90.0 (b) 85.0	310.0 300.4	31.0 21.0
	20	142.0	293.2	20	81.4	293.2	20.8
	19⅞	135.0	277.7	20 20	(a) 81.4 (b) 75.0	293.2 252.6	27.8 15.0
G20	20⅛	120.0	249.1	20 20	(a) 75.0 (b) 70.0	252.6 242.8	30.0 20.0
	20	113.0	234.0	20	65.4	233.8	17.8
	19⅞	107.0	219.7	. .	. .	. .	. .
G18	18⅛	100.0	190.5	18 18	(a) 65.0 (b) 60.0	195.0 186.2	30.0 20.0
	18	93.0	177.0	18	54.7	176.8	16.4
	17⅞	87.5	164.7	. .	. .	. .	. .

The difference in weights does not include separators for assembling the standard beams into girders. The weights of such separators vary from about 1.8 lbs. per foot for 8-inch beams to about 6.4 lbs. per foot for 24-inch beams. The actual weight saved by Bethlehem Girder Beams is increased to the same extent.

COMPARISON OF

BETHLEHEM GIRDER BEAMS

WITH GIRDERS OF TWO AMERICAN STANDARD I BEAMS.

BETHLEHEM GIRDER BEAMS.				GIRDERS COMPOSED OF TWO STANDARD BEAMS.			Weight Saved by Bethlehem Beams, in Pounds per Foot.
Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Section Modulus, Inches.^{3}	Depth of Beams, Inches.	Weight of each Beam, per Foot, Pounds.	Section Modulus of two Beams, Inches.^{3}	
G15b	15⅛	147.0	220.4	15 15	(a) 90.0 (b) 85.0	223.2 215.8	33.0 23.0
	15	141.0	210.4	15	81.3	210.4	21.6
	14⅞	135.0	200.4	15 15	(a) 81.3 (b) 75.0	210.4 183.2	27.6 15.0
G15a	15⅛	111.0	172.8	15 15	(a) 70.0 (b) 65.0	175.8 168.6	29.0 19.0
	15	105.0	162.4	15	60.8	162.4	16.6
	14⅞	99.0	152.5	15 15	(a) 60.8 (b) 55.0	162.4 135.6	22.6 11.0
G15	15⅛	80.5	128.1	15	50.0	128.4	19.5
	15	74.0	117.9	15	42.9	117.8	11.8
	14⅞	69.0	108.4	..	..	..	..
G12a	12⅛	76.5	97.2	12 12	(a) 50.0 (b) 45.0	100.6 94.6	23.5 13.5
	12	70.5	89.7	12	40.8	89.6	11.1
	11⅞	66.0	82.8	..	..	..	..
G12	12⅛	61.0	79.2	12	35.0	75.6	9.0
	12	55.5	72.0	12	31.8	72.0	8.1
	11 29/32	51.5	66.6	..	..	..	..
G10	10⅛	50.0	54.4	10	30.0	53.4	10.0
	10	44.5	48.9	10	25.4	48.8	6.3
	9 29/32	41.5	45.2	..	..	..	..
G9	9⅛	43.5	42.5	9 9	(a) 30.0 (b) 25.0	45.0 40.6	16.5 6.5
	9	38.5	37.9	9	21.8	37.8	5.1
	8 15/16	36.0	35.5	..	..	..	..
G8	8⅛	37.0	32.3	8	23.0	32.0	9.0
	8	33.0	28.6	8	18.4	28.4	3.8
	7 15/16	31.0	26.7	..	..	..	..

NOTE:—The Section Modulus of the Standard Girder marked (a) exceeds that of the Bethlehem Girder Beam.

The Section Modulus of the Standard Girder marked (b) is less than that of the Bethlehem Girder Beam.

COMPARISON OF
BETHLEHEM I BEAMS
WITH AMERICAN STANDARD I BEAMS.

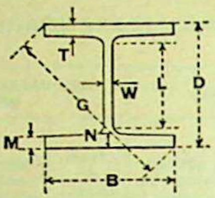
BETHLEHEM I BEAMS.				EQUIVALENT STANDARD BEAMS.			Weight Saved by Bethlehem Beams, in Pounds per Foot.
Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Section Modulus, Inches.^{3}	Depth of Beam, Inches.	Weight per Foot, Pounds.	Section Modulus, Inches.^{3}	
B30	30⅛	129.0	369.6	..	..	..	..
	30	121.0	347.6	..	..	..	..
	29⅞	115.0	327.1	..	..	..	..
B28	28⅛	113.0	304.8	..	..	..	..
	28	106.0	285.3	..	..	..	..
	27⅞	100.0	267.1	..	..	..	..
B26	26⅛	98.0	245.1	..	..	..	..
	26	91.0	227.9	..	..	..	..
	25⅞	85.5	211.9	..	..	..	..
B24b	24 3/32	104.5	246.4	24	115.0	245.0	10.5
	24	99.5	234.3	24	105.9	234.3	6.4
	23 29/32	95.5	222.8	..	..	..	..
B24a	24	84.5	198.3	24	100.0	197.6	15.5
B24	24 3/32	79.5	186.4	24	90.0	185.8	10.5
	24	73.5	173.9	24	79.9	173.9	6.4
B22	22⅛	71.5	154.2	..	..	..	..
	22 1/16	68.5	147.7	..	..	..	..
	22	65.5	140.9	..	..	..	..
B20a	20 3/32	78.0	156.1	20	90.0	155.0	12.0
	20	73.0	146.8	20	81.4	146.6	8.4
B20	20⅛	64.5	127.6	20	75.0	126.3	10.5
	20 1/16	62.0	122.4	20	70.0	121.4	8.0
	20	59.5	117.0	20	65.4	116.9	5.9

COMPARISON OF
BETHLEHEM I BEAMS
WITH AMERICAN STANDARD I BEAMS.

BETHLEHEM I BEAMS.				EQUIVALENT STANDARD BEAMS.			Weight Saved by Bethlehem Beams, in Pounds per Foot.
Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Section Modulus, Inches.^{3}	Depth of Beam, Inches.	Weight per Foot, Pounds.	Section Modulus, Inches.^{3}	
B18a	$18\frac{1}{8}$	74.0	136.6	18	85.0	135.2	11.0
	18	69.0	126.9	18	75.6	126.9	6.6
	$17\frac{7}{8}$	64.5	117.3	..	..	..	..
B18	$18\frac{1}{8}$	54.5	98.1	18	65.0	97.5	10.5
	$18\frac{1}{16}$	52.0	93.5	18	60.0	93.1	8.0
	18	49.0	88.4	18	54.7	88.4	5.7
B15b	15	71.5	105.3	15	81.3	105.2	9.8
B15a	$15\frac{1}{8}$	59.5	88.4	15	70.0	87.9	10.5
	15	54.5	81.3	15	60.8	81.2	6.3
	$14\frac{7}{8}$	50.5	74.7	..	..	..	..
B15	$15\frac{3}{32}$	42.5	64.5	15	50.0	64.2	7.5
	$15\frac{1}{32}$	40.0	61.0	15	45.0	60.5	5.0
	15	38.5	59.0	15	42.9	58.9	4.4
B12a	12	36.5	44.9	12	40.8	44.8	4.3
B12	$12\frac{1}{16}$	31.0	38.5	12	35.0	37.8	4.0
	12	28.5	36.0	12	31.8	36.0	3.3
B10	$10\frac{3}{32}$	26.0	27.1	10	30.0	26.7	4.0
	10	23.5	24.4	10	25.4	24.4	1.9
B9	$9\frac{1}{16}$	22.0	20.5	9	25.0	20.3	3.0
	9	20.5	19.0	9	21.8	18.9	1.3
B8	$8\frac{1}{16}$	19.0	15.6	8	20.5	15.1	1.5
	8	17.5	14.2	8	18.4	14.2	0.9

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 14″ H COLUMNS.

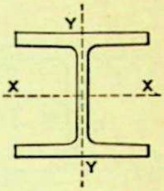


Section Number.	Weight per Foot, Pounds.	DIMENSIONS, IN INCHES.							
		D	Nominal T	B	W	M	N	G	L
H14	84.0	13¾	11/16	13.92	.43	.620	.755	19⅝	L is constant = 11 1/16
	92.0	13⅞	¾	13.96	.47	.683	.817	19¾	
	100.0	14	13/16	14.00	.51	.745	.880	19 13/16	
	107.5	14⅛	⅞	14.04	.55	.808	.942	19 15/16	
	115.5	14¼	15/16	14.08	.59	.870	1.005	20 1/16	
	123.5	14⅜	1	14.12	.63	.933	1.067	20 3/16	
	131.5	14½	1 1/16	14.16	.67	.995	1.130	20¼	
	139.0	14⅝	1⅛	14.19	.70	1.058	1.192	20⅜	
	147.0	14¾	1 3/16	14.23	.74	1.120	1.255	20½	
	155.0	14⅞	1¼	14.27	.78	1.183	1.317	20⅝	
	163.0	15	1 5/16	14.31	.82	1.245	1.380	20¾	
	171.5	15⅛	1⅜	14.35	.86	1.308	1.442	20⅞	
	179.5	15¼	1 7/16	14.39	.90	1.370	1.505	21	
	187.5	15⅜	1½	14.43	.94	1.433	1.567	21⅛	
	196.0	15½	1 9/16	14.47	.98	1.495	1.630	21¼	
	204.5	15⅝	1⅝	14.51	1.02	1.558	1.692	21⅜	
	212.0	15¾	1 11/16	14.54	1.05	1.620	1.755	21 7/16	
	220.5	15⅞	1¾	14.58	1.09	1.683	1.817	21 9/16	
	228.5	16	1 13/16	14.62	1.13	1.745	1.880	21 11/16	
	237.0	16⅛	1⅞	14.66	1.17	1.808	1.942	21 13/16	
	245.5	16¼	1 15/16	14.70	1.21	1.870	2.005	21 15/16	
	254.0	16⅜	2	14.74	1.25	1.933	2.067	22 1/16	
	262.5	16½	2 1/16	14.78	1.29	1.995	2.130	22 3/16	
	271.0	16⅝	2⅛	14.82	1.33	2.058	2.192	22 5/16	
	279.5	16¾	2 3/16	14.86	1.37	2.120	2.255	22 7/16	
	288.5	16⅞	2¼	14.90	1.41	2.183	2.317	22 9/16	

For 14″ Columns of lighter weight see pages 64 and 65.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 14″ H COLUMNS.

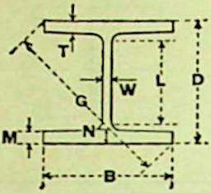


		AXIS X-X.				AXIS Y-Y.			
Weight per Foot, Pounds.	Area, Square Inches.	Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Bending Factor. k	Moment of Inertia, Inches.^{4} I′	Section Modulus, Inches.^{3} S′	Radius of Gyration, Inches. r′	Bending Factor. k′
84.0	24.46	884.9	128.7	6.01	.190	294.5	42.3	3.47	.578
92.0	26.76	976.8	140.8	6.04	.190	325.4	46.6	3.49	.574
100.0	29.06	1070.6	153.0	6.07	.190	356.9	51.0	3.50	.570
107.5	31.38	1166.6	165.2	6.10	.190	388.9	55.4	3.52	.566
115.5	33.70	1264.5	177.5	6.13	.190	421.3	59.9	3.54	.563
123.5	36.04	1364.6	189.9	6.16	.190	454.4	64.4	3.55	.560
131.5	38.38	1466.7	202.3	6.18	.190	487.9	68.9	3.57	.557
139.0	40.59	1568.4	214.5	6.21	.189	520.9	73.4	3.58	.553
147.0	42.95	1674.7	227.1	6.24	.189	555.4	78.1	3.60	.550
155.0	45.33	1783.3	239.8	6.27	.189	590.5	82.8	3.61	.548
163.0	47.71	1894.0	252.5	6.30	.189	626.1	87.5	3.62	.545
171.5	50.11	2007.0	265.4	6.33	.189	662.3	92.3	3.64	.543
179.5	52.51	2122.3	278.3	6.36	.189	699.0	97.2	3.65	.541
187.5	54.92	2239.8	291.4	6.39	.189	736.3	102.1	3.66	.538
196.0	57.35	2359.7	304.5	6.41	.188	774.2	107.0	3.68	.536
204.5	59.78	2481.9	317.7	6.44	.188	812.6	112.0	3.69	.534
212.0	62.07	2603.3	330.6	6.48	.188	849.8	116.9	3.70	.531
220.5	64.52	2730.2	344.0	6.51	.188	889.3	122.0	3.71	.529
228.5	66.98	2859.6	357.5	6.53	.187	929.4	127.1	3.72	.527
237.0	69.45	2991.5	371.0	6.56	.187	970.0	132.3	3.74	.525
245.5	71.94	3125.8	384.7	6.59	.187	1011.3	137.6	3.75	.523
254.0	74.43	3262.7	398.5	6.62	.187	1053.2	142.9	3.76	.521
262.5	76.93	3402.1	412.4	6.65	.187	1095.6	148.3	3.77	.519
271.0	79.44	3544.1	426.4	6.68	.186	1138.7	153.7	3.79	.517
279.5	81.97	3688.8	440.5	6.71	.186	1182.4	159.1	3.80	.515
288.5	84.50	3836.1	454.7	6.74	.186	1226.7	164.7	3.81	.513

For 14″ Columns of lighter weight see pages 64 and 65.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 12″ H COLUMNS.

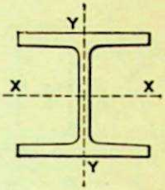


Section Number.	Weight per Foot, Pounds.	DIMENSIONS, IN INCHES.							
		D	Nominal. T	B	W	M	N	G	L
H12	65.5	11¾	⅝	11.92	.39	.567	.683	16¾	L is constant = 9³⁄₁₆
	72.5	11⅞	¹¹⁄₁₆	11.96	.43	.630	.745	16⅞	
	79.0	12	¾	12.00	.47	.692	.808	17	
	85.5	12⅛	¹³⁄₁₆	12.04	.51	.755	.870	17⅛	
	92.5	12¼	⅞	12.08	.55	.817	.933	17¼	
	99.5	12⅜	¹⁵⁄₁₆	12.12	.59	.880	.995	17⅜	
	106.0	12½	1	12.16	.63	.942	1.058	17⁷⁄₁₆	
	113.0	12⅝	1¹⁄₁₆	12.20	.67	1.005	1.120	17⁹⁄₁₆	
	119.5	12¾	1⅛	12.23	.70	1.067	1.183	17¹¹⁄₁₆	
	126.5	12⅞	1³⁄₁₆	12.27	.74	1.130	1.245	17¹³⁄₁₆	
	133.5	13	1¼	12.31	.78	1.192	1.308	17¹⁵⁄₁₆	
	140.5	13⅛	1⁵⁄₁₆	12.35	.82	1.255	1.370	18	
	147.5	13¼	1⅜	12.39	.86	1.317	1.433	18⅛	
	154.5	13⅜	1⁷⁄₁₆	12.43	.90	1.380	1.495	18¼	
	162.0	13½	1½	12.47	.94	1.442	1.558	18⅜	
	169.0	13⅝	1⁹⁄₁₆	12.51	.98	1.505	1.620	18½	
	176.0	13¾	1⅝	12.55	1.02	1.567	1.683	18⅝	
	183.0	13⅞	1¹¹⁄₁₆	12.58	1.05	1.630	1.745	18¾	
	190.0	14	1¾	12.62	1.09	1.692	1.808	18¹³⁄₁₆	

For 12″ Columns of lighter weight see pages 64 and 65.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 12″ H COLUMNS.

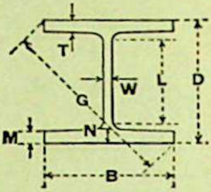


Weight per Foot, Pounds.	Area, Square Inches.	AXIS X-X.				AXIS Y-Y.			
		Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Bending Factor. k	Moment of Inertia, Inches.^{4} I′	Section Modulus, Inches.^{3} S′	Radius of Gyration, Inches. r′	Bending Factor. k′
65.5	19.00	499.0	84.9	5.13	.224	168.6	28.3	2.98	.672
72.5	20.96	556.6	93.7	5.15	.224	188.2	31.5	3.00	.666
79.0	22.94	615.6	102.6	5.18	.224	208.1	34.7	3.01	.661
85.5	24.92	676.1	111.5	5.21	.224	228.5	37.9	3.03	.657
92.5	26.92	738.1	120.5	5.24	.223	249.2	41.3	3.04	.652
99.5	28.92	801.7	129.6	5.27	.223	270.1	44.6	3.06	.649
106.0	30.94	866.8	138.6	5.30	.223	291.7	48.0	3.07	.645
113.0	32.96	933.4	147.9	5.33	.223	313.6	51.4	3.08	.641
119.5	34.87	1000.0	156.9	5.36	.222	335.0	54.8	3.10	.637
126.5	36.91	1069.8	166.2	5.38	.222	357.7	58.3	3.11	.633
133.5	38.97	1141.3	175.6	5.41	.222	380.7	61.9	3.13	.630
140.5	41.03	1214.5	185.0	5.44	.222	404.1	65.4	3.14	.627
147.5	43.10	1289.4	194.6	5.47	.221	428.0	69.1	3.15	.624
154.5	45.19	1366.0	204.3	5.50	.221	452.2	72.8	3.16	.621
162.0	47.28	1444.3	214.0	5.53	.221	477.0	76.5	3.18	.618
169.0	49.38	1524.4	223.8	5.56	.221	502.1	80.3	3.19	.615
176.0	51.50	1606.3	233.6	5.59	.220	527.6	84.1	3.20	.612
183.0	53.48	1687.8	243.3	5.62	.220	552.2	87.8	3.21	.609
190.0	55.62	1773.4	253.3	5.65	.220	578.6	91.7	3.23	.607

For 12″ Columns of lighter weight see pages 64 and 65.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 10″ H COLUMNS.

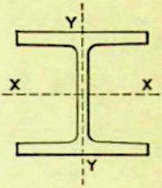


Section Number.	Weight per Foot, Pounds.	DIMENSIONS, IN INCHES.							
			Nominal.						
		D	T	B	W	M	N	G	L
H10	49.5	9⅞	9/16	9.97	.36	.514	.611	14 1/16	L is constant = 7 11/16
	55.0	10	⅝	10.00	.39	.577	.673	14 3/16	
	60.5	10⅛	11/16	10.04	.43	.639	.736	14 5/16	
	66.0	10¼	¾	10.08	.47	.702	.798	14⅜	
	72.0	10⅜	13/16	10.12	.51	.764	.861	14½	
	77.5	10½	⅞	10.16	.55	.827	.923	14⅝	
	83.5	10⅝	15/16	10.20	.59	.889	.986	14¾	
	89.0	10¾	1	10.24	.63	.952	1.048	14⅞	
	95.0	10⅞	1 1/16	10.28	.67	1.014	1.111	15	
	100.5	11	1⅛	10.31	.70	1.077	1.173	15⅛	
	106.5	11⅛	1 3/16	10.35	.74	1.139	1.236	15 3/16	
	112.0	11¼	1¼	10.39	.78	1.202	1.298	15 5/16	
	118.0	11⅜	1 5/16	10.43	.82	1.264	1.361	15 7/16	
	124.0	11½	1⅜	10.47	.86	1.327	1.423	15 9/16	
	130.0	11⅝	1 7/16	10.51	.90	1.389	1.486	15 11/16	
	136.5	11¾	1½	10.55	.94	1.452	1.548	15 13/16	

For 10″ Columns of lighter weight see pages 66 and 67.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 10″ H COLUMNS.

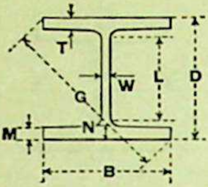


Weight per Foot, Pounds.	Area, Square Inches.	AXIS X-X.				AXIS Y-Y.			
		Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Bending Factor. k	Moment of Inertia, Inches.^{4} I′	Section Modulus, Inches.^{3} S′	Radius of Gyration, Inches. r′	Bending Factor. k′
49.5	14.37	263.5	53.4	4.28	.269	89.1	17.9	2.49	.804
55.0	15.91	296.8	59.4	4.32	.268	100.4	20.1	2.51	.792
60.5	17.57	331.9	65.6	4.35	.268	112.2	22.3	2.53	.786
66.0	19.23	368.0	71.8	4.37	.268	124.2	24.6	2.54	.780
72.0	20.91	405.2	78.1	4.40	.268	136.5	27.0	2.56	.775
77.5	22.59	443.6	84.5	4.43	.267	149.1	29.4	2.57	.770
83.5	24.29	483.0	90.9	4.46	.267	162.0	31.8	2.58	.765
89.0	25.99	523.5	97.4	4.49	.267	175.1	34.2	2.60	.760
95.0	27.71	565.2	103.9	4.52	.267	188.6	36.7	2.61	.755
100.5	29.32	607.0	110.4	4.55	.266	201.7	39.1	2.62	.749
106.5	31.06	651.0	117.0	4.58	.265	215.6	41.7	2.64	.746
112.0	32.80	696.2	123.8	4.61	.265	229.9	44.3	2.65	.741
118.0	34.55	742.7	130.6	4.64	.265	244.4	46.9	2.66	.737
124.0	36.32	790.4	137.5	4.67	.264	259.3	49.5	2.67	.733
130.0	38.09	839.4	144.4	4.69	.264	274.5	52.2	2.68	.729
136.5	39.88	889.7	151.4	4.72	.263	289.9	55.0	2.70	.726

For 10″ Columns of lighter weight see pages 66 and 67.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 8″ H COLUMNS.

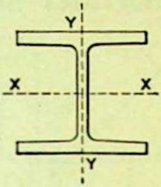


Section Number.	Weight per Foot, Pounds.	DIMENSIONS, IN INCHES.							
		D	Nominal. T	B	W	M	N	G	L
H8	32.0	7⅞	7/16	8.00	.31	.399	.476	11¼	L is constant = 6⅛
	35.0	8	½	8.00	.31	.462	.538	11⅜	
	39.5	8⅛	9/16	8.04	.35	.524	.601	11 7/16	
	44.0	8¼	⅝	8.08	.39	.587	.663	11 9/16	
	48.5	8⅜	11/16	8.12	.43	.649	.726	11 11/16	
	53.0	8½	¾	8.16	.47	.712	.788	11 13/16	
	58.0	8⅝	13/16	8.20	.51	.774	.851	12	
	62.5	8¾	⅞	8.24	.55	.837	.913	12 1/16	
	67.5	8⅞	15/16	8.28	.59	.899	.976	12⅛	
	72.0	9	1	8.32	.63	.962	1.038	12¼	
	77.0	9⅛	1 1/16	8.36	.67	1.024	1.101	12⅜	
	81.5	9¼	1⅛	8.39	.70	1.087	1.163	12½	
	86.0	9⅜	1 3/16	8.43	.74	1.149	1.226	12⅝	
	91.0	9½	1¼	8.47	.78	1.212	1.288	12¾	

For 8″ Columns of lighter weight see pages 66 and 67.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 8″ H COLUMNS.



Weight per Foot, Pounds.	Area, Square Inches.	AXIS X-X.				AXIS Y-Y.			
		Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Bending Factor. k	Moment of Inertia, Inches.^{4} I′	Section Modulus, Inches.^{3} S′	Radius of Gyration, Inches. r′	Bending Factor. k′
32.0	9.17	105.7	26.9	3.40	.342	35.8	8.9	1.98	1.025
35.0	10.17	121.5	30.4	3.46	.335	41.1	10.3	2.01	.990
39.5	11.50	139.5	34.3	3.48	.335	47.2	11.7	2.03	.979
44.0	12.83	158.3	38.4	3.51	.334	53.4	13.2	2.04	.971
48.5	14.18	177.7	42.4	3.54	.334	59.8	14.7	2.05	.963
53.0	15.53	197.8	46.5	3.57	.334	66.3	16.3	2.07	.956
58.0	16.90	218.6	50.7	3.60	.333	73.1	17.8	2.08	.948
62.5	18.27	240.2	54.9	3.63	.333	80.0	19.4	2.09	.941
67.5	19.66	262.5	59.2	3.65	.332	87.1	21.0	2.11	.934
72.0	21.05	285.6	63.5	3.68	.332	94.4	22.7	2.12	.928
77.0	22.46	309.5	67.8	3.71	.331	101.9	24.4	2.13	.921
81.5	23.78	333.5	72.1	3.75	.330	109.2	26.0	2.14	.914
86.0	25.20	359.0	76.6	3.77	.329	117.1	27.8	2.16	.907
91.0	26.64	385.3	81.1	3.80	.328	125.1	29.6	2.17	.902

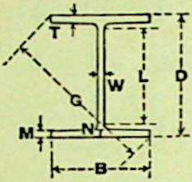
For 8″ Columns of lighter weight see pages 66 and 67.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM COLUMNS.

14″ AND 12″

SUPPLEMENTARY SECTIONS.



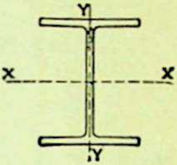
Section Number.	Weight per Foot, Pounds.	DIMENSIONS, IN INCHES.							
		Nominal. D	Nominal. T	B	W	M	N	G	L
$H\frac{14}{8}$	43.0	$13\frac{3}{8}$	$\frac{1}{2}$	8.00	.31	.491	.567	$15\frac{9}{16}$	$11\frac{1}{16}$
	48.0	$13\frac{1}{2}$	$\frac{9}{16}$	8.04	.35	.553	.630	$15\frac{11}{16}$	$11\frac{1}{16}$
	53.5	$13\frac{5}{8}$	$\frac{5}{8}$	8.08	.39	.616	.692	$15\frac{13}{16}$	$11\frac{1}{16}$
	58.5	$13\frac{3}{4}$	$\frac{11}{16}$	8.12	.43	.678	.755	16	$11\frac{1}{16}$
$H\frac{14}{10}$	55.0	$13\frac{1}{2}$	$\frac{9}{16}$	10.00	.35	.533	.630	$16\frac{13}{16}$	$11\frac{1}{16}$
	61.5	$13\frac{5}{8}$	$\frac{5}{8}$	10.04	.39	.596	.692	$16\frac{15}{16}$	$11\frac{1}{16}$
	67.5	$13\frac{3}{4}$	$\frac{11}{16}$	10.08	.43	.658	.755	$17\frac{1}{16}$	$11\frac{1}{16}$
	73.5	$13\frac{7}{8}$	$\frac{3}{4}$	10.12	.47	.721	.817	$17\frac{3}{16}$	$11\frac{1}{16}$
$H\frac{14}{12}$	69.0	$13\frac{5}{8}$	$\frac{5}{8}$	12.00	.39	.576	.692	$18\frac{1}{8}$	$11\frac{1}{16}$
	76.0	$13\frac{3}{4}$	$\frac{11}{16}$	12.04	.43	.639	.755	$18\frac{1}{4}$	$11\frac{1}{16}$
	83.0	$13\frac{7}{8}$	$\frac{3}{4}$	12.08	.47	.701	.817	$18\frac{3}{8}$	$11\frac{1}{16}$
	90.0	14	$\frac{13}{16}$	12.12	.51	.764	.880	$18\frac{1}{2}$	$11\frac{1}{16}$
$H\frac{12}{8}$	40.5	$11\frac{1}{2}$	$\frac{1}{2}$	8.00	.31	.481	.558	14	$9\frac{3}{16}$
	45.5	$11\frac{5}{8}$	$\frac{9}{16}$	8.04	.35	.543	.620	$14\frac{1}{8}$	$9\frac{3}{16}$
	50.5	$11\frac{3}{4}$	$\frac{5}{8}$	8.08	.39	.606	.683	$14\frac{1}{4}$	$9\frac{3}{16}$
	55.0	$11\frac{7}{8}$	$\frac{11}{16}$	8.12	.43	.668	.745	$14\frac{3}{8}$	$9\frac{3}{16}$
$H\frac{12}{10}$	52.5	$11\frac{5}{8}$	$\frac{9}{16}$	10.00	.35	.524	.620	$15\frac{5}{16}$	$9\frac{3}{16}$
	58.0	$11\frac{3}{4}$	$\frac{5}{8}$	10.04	.39	.586	.683	$15\frac{7}{16}$	$9\frac{3}{16}$
	64.0	$11\frac{7}{8}$	$\frac{11}{16}$	10.08	.43	.649	.745	$15\frac{9}{16}$	$9\frac{3}{16}$
	70.0	12	$\frac{3}{4}$	10.12	.47	.711	.808	$15\frac{11}{16}$	$9\frac{3}{16}$

DIMENSIONS AND PROPERTIES OF

BETHLEHEM COLUMNS.

14″ AND 12″

SUPPLEMENTARY SECTIONS.

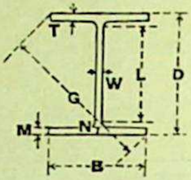


		AXIS X-X.				AXIS Y-Y.			
Weight per Foot, Pounds.	Area, Square Inches.	Moment of Inertia, Inches.^{4}	Section Modulus, Inches.^{3}	Radius of Gyration, Inches.	Bending Factor.	Moment of Inertia, Inches.^{4}	Section Modulus, Inches.^{3}	Radius of Gyration, Inches.	Bending Factor.
		I	S	r	k	I′	S′	r′	k′
43.0	12.28	397.6	59.5	5.69	.207	43.6	10.9	1.88	1.127
48.0	13.82	450.9	66.8	5.71	.207	49.7	12.4	1.90	1.118
53.5	15.37	505.6	74.2	5.74	.207	56.0	13.9	1.91	1.110
58.5	16.93	561.6	81.7	5.76	.207	62.4	15.4	1.92	1.102
55.0	15.95	540.4	80.1	5.82	.199	93.1	18.6	2.42	.857
61.5	17.75	606.3	89.0	5.84	.199	104.8	20.9	2.43	.850
67.5	19.55	673.7	98.0	5.87	.200	116.8	23.2	2.44	.844
73.5	21.37	742.7	107.1	5.90	.200	129.0	25.5	2.46	.838
69.0	20.04	704.0	103.3	5.93	.194	174.7	29.1	2.95	.689
76.0	22.09	782.9	113.9	5.95	.194	194.7	32.3	2.97	.683
83.0	24.15	863.6	124.5	5.98	.194	215.0	35.6	2.98	.678
90.0	26.22	946.1	135.2	6.01	.194	235.8	38.9	3.00	.674
40.5	11.55	280.1	48.7	4.92	.237	42.8	10.7	1.92	1.081
45.5	13.02	318.8	54.8	4.95	.237	48.8	12.1	1.94	1.071
50.5	14.49	358.5	61.0	4.97	.237	55.1	13.6	1.95	1.063
55.0	15.98	399.3	67.3	5.00	.238	61.5	15.2	1.96	1.055
52.5	15.11	383.2	65.9	5.04	.229	91.5	18.3	2.46	.826
58.0	16.83	431.3	73.4	5.06	.229	103.2	20.5	2.48	.819
64.0	18.56	480.6	80.9	5.09	.229	115.1	22.8	2.49	.813
70.0	20.30	531.3	88.5	5.12	.229	127.3	25.2	2.50	.807

DIMENSIONS AND PROPERTIES OF

BETHLEHEM COLUMNS.

10″, 8″ AND 6″ SUPPLEMENTARY SECTIONS.



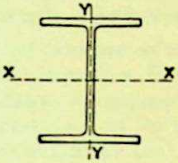
Section Number.	Weight per Foot, Pounds.	DIMENSIONS, IN INCHES.							
		Nominal.	Nominal.						
		D	T	B	W	M	N	G	L
$H\frac{10}{8}$	33.5	9⅝	7/16	8.00	.28	.408	.486	12½	7 11/16
	38.0	9¾	½	8.03	.31	.471	.548	12⅝	7 11/16
	42.5	9⅞	9/16	8.07	.35	.533	.611	12¾	7 11/16
	47.5	10	⅝	8.11	.39	.596	.673	12⅞	7 11/16
$H\frac{8}{6.5}$	23.5	7¾	⅜	6.50	.25	.351	.413	10⅛	6⅛
	27.0	7⅞	7/16	6.53	.28	.413	.476	10¼	6⅛
	30.5	8	½	6.56	.31	.476	.538	10⅜	6⅛
	34.5	8⅛	9/16	6.60	.35	.538	.601	10½	6⅛
H6	20.0	6	⅜	6.00	.25	.346	.404	8½	4⅝
	23.0	6⅛	7/16	6.02	.27	.409	.466	8 9/16	4⅝
	26.5	6¼	½	6.06	.31	.471	.529	8 11/16	4⅝
	30.0	6⅜	9/16	6.10	.35	.534	.591	8 13/16	4⅝
	33.5	6½	⅝	6.14	.39	.596	.654	8 15/16	4⅝
	37.0	6⅝	11/16	6.18	.43	.659	.716	9 1/16	4⅝
	40.5	6¾	¾	6.22	.47	.721	.779	9 3/16	4⅝

DIMENSIONS AND PROPERTIES OF

BETHLEHEM COLUMNS.

10″, 8″ AND 6″

SUPPLEMENTARY SECTIONS.



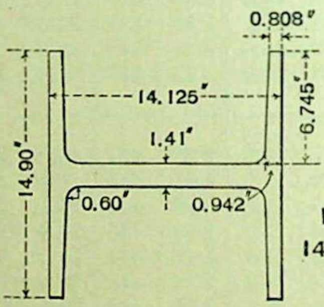
Weight per Foot, Pounds.	Area, Square Inches.	AXIS X-X.				AXIS Y-Y.			
		Moment of Inertia, Inches.^{4}	Section Modulus, Inches.^{3}	Radius of Gyration, Inches.	Bending Factor.	Moment of Inertia, Inches.^{4}	Section Modulus, Inches.^{3}	Radius of Gyration, Inches.	Bending Factor.
		I	S	r	k	I′	S′	r′	k′
33.5	9.60	166.2	34.5	4.16	.278	36.6	9.14	1.95	1.050
38.0	10.89	192.0	39.4	4.20	.276	42.4	10.56	1.97	1.031
42.5	12.29	219.4	44.4	4.23	.277	48.5	12.02	1.99	1.022
47.5	13.70	247.6	49.5	4.25	.277	54.8	13.52	2.00	1.013
23.5	6.72	74.6	19.2	3.33	.349	16.8	5.17	1.58	1.298
27.0	7.76	88.2	22.4	3.37	.347	20.0	6.11	1.60	1.270
30.5	8.82	102.3	25.6	3.41	.345	23.2	7.07	1.62	1.248
34.5	9.97	117.4	28.9	3.43	.345	26.6	8.07	1.63	1.236
20.0	5.81	38.7	12.9	2.58	.451	13.0	4.34	1.50	1.340
23.0	6.69	45.9	15.0	2.62	.446	15.4	5.12	1.52	1.305
26.5	7.69	53.9	17.3	2.65	.445	18.1	5.96	1.53	1.290
30.0	8.70	62.4	19.6	2.68	.445	20.8	6.82	1.55	1.277
33.5	9.72	71.2	21.9	2.71	.444	23.6	7.69	1.56	1.264
37.0	10.76	80.4	24.3	2.73	.443	26.6	8.59	1.57	1.251
40.5	11.80	90.1	26.7	2.76	.442	29.6	9.52	1.58	1.240

REINFORCED 14″ H COLUMNS AND SPECIAL COMPOUND COLUMNS.

When columns are required of greater sectional area than the regular sections of H columns, it is necessary to reinforce the latter to obtain the desired area. This may be the case in the columns for the lower stories of a high building.

Additional area may be secured by riveting plates to the flanges of the regular H columns. In general this is the simplest and most economical method of reinforcement. Dimensions and properties of such reinforced 14″ H columns are given on pages 70 and 71 in the table of Reinforced 14″ H Columns.

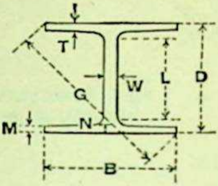
If it is desired to avoid drilling the thick metal of the flanges of the heavy H columns, for attaching the cover plates, the Bethlehem 14″ Special H Section, H 14b, shown below, may be used. Dimensions and properties of this special section are given on the opposite page. This special section is produced by the same rolls and has the same inner contour as the regular series of 14″ H columns on page 56, which can be spliced to this special section in the usual way. This section permits the addition of plates, or other shapes, for increasing the area to the desired extent, in the manner indicated by Figs. 1–3 on the opposite page, avoiding the drilling of thick metal in the flanges. Dimensions and properties of heavy columns, made of this Bethlehem 14″ Special H Section with cover plates, are given on pages 72 and 73 in the table of Special Compound Columns.

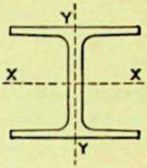


H14 b
149.0 Lbs.

DIMENSIONS AND PROPERTIES OF

BETHLEHEM 14″ SPECIAL H SECTION.





DIMENSIONS.

Section Number.	Weight per Foot, Pounds.	Dimensions, in Inches.							
		D	Nominal. T	B	W	M	N	G	L
H14b	149.0	14⅛	⅞	14.90	1.41	.808	.942	20⅞	11$\frac{1}{16}$

PROPERTIES.

Section Number.	Weight per Foot, Pounds.	Area, Square Inches.	Axis X-X.			Axis Y-Y.		
			Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Moment of Inertia, Inches.^{4} I′	Section Modulus, Inches.^{3} S′	Radius of Gyration, Inches. r′
H14b	149.0	43.52	1368.5	193.8	5.61	468.6	62.9	3.28

SUGGESTIONS FOR USING THE BETHLEHEM 14″ SPECIAL H SECTION IN BUILDING UP COLUMNS OF LARGE SECTIONAL AREA.

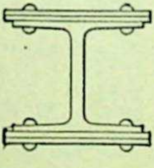


Fig. 1.

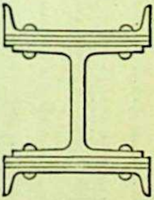


Fig. 2.

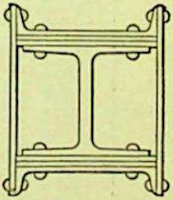
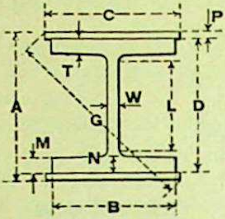


Fig. 3.

DIMENSIONS AND PROPERTIES OF

REINFORCED 14″ H COLUMNS.

BETHLEHEM 14″ H COLUMNS



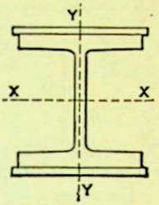
REINFORCED WITH COVER PLATES.

Section Reinforced.	Weight of Column per Foot, Pounds.	DIMENSIONS, IN INCHES.				
		COVER PLATES.		Depth of Column.	Diagonal Diameter.	Dimensions of H Column.
		Width. C	Thickness. P	A	G	
H14 254.0 Lbs. per foot.	294.8	16	⅜	17⅛	23 7/16	D = 16⅜ T = 2 B = 14.74 W = 1.25 M = 1.933 N = 2.067 L = 11 1/16
	301.6	16	7/16	17¼	23½	
	308.4	16	½	17⅜	23⅝	
	315.2	16	9/16	17½	23 11/16	
	322.0	16	⅝	17⅝	23 13/16	
	328.8	16	11/16	17¾	23⅞	
	335.6	16	¾	17⅞	24	
	342.4	16	13/16	18	24 1/16	
	349.2	16	⅞	18⅛	24 3/16	
	356.0	16	15/16	18¼	24¼	
H14 288.5 Lbs. per foot.	360.8	17	⅝	18⅛	24⅞	D = 16⅞ T = 2¼ B = 14.90 W = 1.41 M = 2.183 N = 2.317 L = 11 1/16
	368.0	17	11/16	18¼	24 15/16	
	375.2	17	¾	18⅜	25 1/16	
	382.4	17	13/16	18½	25⅛	
	389.7	17	⅞	18⅝	25¼	
	396.9	17	15/16	18¾	25 5/16	
	404.1	17	1	18⅞	25⅜	
	411.3	17	1 1/16	19	25½	
	418.6	17	1⅛	19⅛	25 9/16	
H14 288.5 Lbs. per foot.	426.2	18	1⅛	19⅛	26¼	
	433.9	18	1 3/16	19¼	26⅜	
	441.5	18	1¼	19⅜	26 7/16	
	449.2	18	1 5/16	19½	26 9/16	
	456.8	18	1⅜	19⅝	26⅝	
	464.5	18	1 7/16	19¾	26¾	
	472.1	18	1½	19⅞	26 13/16	
	479.8	18	1 9/16	20	26 15/16	
	487.4	18	1⅝	20⅛	27	
	495.1	18	1 11/16	20¼	27⅛	
	502.7	18	1¾	20⅜	27 3/16	

DIMENSIONS AND PROPERTIES OF

REINFORCED 14" H COLUMNS.

BETHLEHEM
14" H COLUMNS



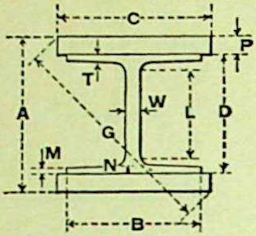
REINFORCED WITH
COVER PLATES.

Weight of Column per Foot, Pounds.	Area of Column, Square Inches.	AXIS X-X.				AXIS Y-Y.			
		Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Bending Factor. k	Moment of Inertia, Inches.^{4} I′	Section Modulus, Inches.^{3} S′	Radius of Gyration, Inches. r′	Bending Factor. k′
294.8	86.43	4104.5	479.4	6.89	.180	1309.2	163.6	3.89	.528
301.6	88.43	4252.2	493.0	6.93	.179	1351.8	169.0	3.91	.523
308.4	90.43	4402.1	506.7	6.98	.178	1394.5	174.3	3.93	.519
315.2	92.43	4554.1	520.5	7.02	.178	1437.2	179.6	3.94	.515
322.0	94.43	4708.3	534.3	7.06	.177	1479.8	185.0	3.96	.510
328.8	96.43	4864.8	548.1	7.10	.176	1522.5	190.3	3.97	.507
335.6	98.43	5023.4	562.1	7.14	.175	1565.2	195.6	3.99	.503
342.4	100.43	5184.3	576.0	7.18	.174	1607.8	201.0	4.00	.500
349.2	102.43	5347.4	590.1	7.23	.174	1650.5	206.3	4.01	.496
356.0	104.43	5512.8	604.1	7.27	.173	1693.2	211.6	4.03	.493
360.8	105.75	5463.7	602.9	7.19	.175	1738.5	204.5	4.06	.517
368.0	107.87	5639.4	618.0	7.23	.175	1789.6	210.5	4.07	.512
375.2	110.00	5817.6	633.2	7.27	.174	1840.8	216.6	4.09	.508
382.4	112.12	5998.2	648.5	7.31	.173	1892.0	222.6	4.11	.504
389.7	114.25	6181.2	663.8	7.36	.172	1943.2	228.6	4.12	.500
396.9	116.37	6366.8	679.1	7.40	.171	1994.3	234.6	4.14	.496
404.1	118.50	6554.8	694.5	7.44	.171	2045.5	240.6	4.15	.492
411.3	120.62	6745.3	710.0	7.48	.170	2096.7	246.7	4.17	.489
418.6	122.75	6938.3	725.6	7.52	.169	2147.9	252.7	4.18	.486
426.2	125.00	7120.8	744.7	7.55	.168	2320.2	257.8	4.31	.485
433.9	127.25	7327.9	761.3	7.59	.167	2380.9	264.5	4.33	.481
441.5	129.50	7537.7	778.1	7.63	.166	2441.7	271.3	4.34	.477
449.2	131.75	7750.2	794.9	7.67	.166	2502.4	278.0	4.36	.474
456.8	134.00	7965.5	811.8	7.71	.165	2563.2	284.8	4.37	.471
464.5	136.25	8183.5	828.7	7.75	.164	2623.9	291.5	4.39	.467
472.1	138.50	8404.3	845.7	7.79	.164	2684.7	298.3	4.40	.464
479.8	140.75	8627.9	862.8	7.83	.163	2745.4	305.0	4.42	.461
487.4	143.00	8854.3	879.9	7.87	.163	2806.2	311.8	4.43	.459
495.1	145.25	9083.6	897.1	7.91	.162	2866.9	318.5	4.44	.456
502.7	147.50	9315.7	914.4	7.95	.161	2927.7	325.3	4.46	.453

DIMENSIONS AND PROPERTIES OF

SPECIAL COMPOUND COLUMNS.

BETHLEHEM
14⅛" X 149 LBS.
SPECIAL H SECTION.



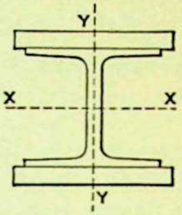
REINFORCED
WITH
COVER PLATES.

Section of Column.	Weight of Column per Foot, Pounds.	DIMENSIONS, IN INCHES.				
		COVER PLATES.		Depth of Column. A	Diagonal Diameter. G	Dimensions of 14" Special H Section.
		Width. C	Thickness. P			
Columns composed of a 14⅛" x 149 Lbs. Special H Section (Section H14b), reinforced with cover plates of width and thickness given in table. The total thickness, P, may be made of two or more plates, each of punchable thickness.	285.0	16	1¼	16⅝	23 1/16	D 14⅛ T ⅞ B 14.90 W 1.41 M 0.808 N 0.942 L 11 1/16
	291.8	16	1 5/16	16¾	23 3/16	
	298.6	16	1⅜	16⅞	23¼	
	305.4	16	1 7/16	17	23⅜	
	312.2	16	1½	17⅛	23 7/16	
	319.0	16	1 9/16	17¼	23½	
	325.8	16	1⅝	17⅜	23⅝	
	332.6	16	1 11/16	17½	23 11/16	
	339.4	16	1¾	17⅝	23 13/16	
	346.2	16	1 13/16	17¾	23⅞	
	351.3	17	1¾	17⅝	24½	
	358.5	17	1 13/16	17¾	24 9/16	
	365.7	17	1⅞	17⅞	24 11/16	
	373.0	17	1 15/16	18	24¾	
	380.2	17	2	18⅛	24⅞	
	387.4	17	2 1/16	18¼	24 15/16	
	394.6	17	2⅛	18⅜	25 1/16	
	401.9	17	2 3/16	18½	25⅛	
	409.1	17	2¼	18⅝	25 3/16	
	416.3	17	2 5/16	18¾	25 5/16	
	424.4	18	2¼	18⅝	25⅞	
	432.0	18	2 5/16	18¾	26	
	439.7	18	2⅜	18⅞	26 1/16	
	447.3	18	2 7/16	19	26 3/16	
	455.0	18	2½	19⅛	26¼	
	462.6	18	2 9/16	19¼	26⅜	
	470.3	18	2⅝	19⅜	26 7/16	
	477.9	18	2 11/16	19½	26 9/16	
	485.6	18	2¾	19⅝	26⅝	
	493.2	18	2 13/16	19¾	26¾	
	500.9	18	2⅞	19⅞	26 13/16	

DIMENSIONS AND PROPERTIES OF

SPECIAL COMPOUND COLUMNS.

BETHLEHEM
14⅛″ X 149 LBS.
SPECIAL H SECTION.



REINFORCED
WITH
COVER PLATES.

Weight of Column per Foot, Pounds.	Area of Column, Square Inches.	AXIS X-X.				AXIS Y-Y.			
		Moment of Inertia, Inches.^{4} I	Section Modulus, Inches.^{3} S	Radius of Gyration, Inches. r	Bending Factor. k	Moment of Inertia, Inches.^{4} I'	Section Modulus, Inches.^{3} S'	Radius of Gyration, Inches. r'	Bending Factor. k'
285.0	83.52	3737.6	449.6	6.69	.186	1322.0	165.2	3.98	.505
291.8	85.52	3876.9	462.9	6.73	.185	1364.6	170.6	3.99	.501
298.6	87.52	4018.2	476.2	6.78	.184	1407.3	175.9	4.01	.498
305.4	89.52	4161.7	489.6	6.82	.183	1450.0	181.2	4.02	.494
312.2	91.52	4307.2	503.0	6.86	.182	1492.6	186.6	4.04	.491
319.0	93.52	4454.9	516.5	6.90	.181	1535.3	191.9	4.05	.487
325.8	95.52	4604.8	530.0	6.94	.180	1578.0	197.2	4.06	.484
332.6	97.52	4756.8	543.6	6.98	.179	1620.6	202.6	4.08	.481
339.4	99.52	4911.0	557.3	7.02	.179	1663.3	207.9	4.09	.479
346.2	101.52	5067.5	571.0	7.07	.178	1706.0	213.2	4.10	.476
351.3	103.02	5132.5	582.4	7.06	.177	1901.6	223.7	4.30	.460
358.5	105.15	5298.7	597.0	7.10	.176	1952.8	229.7	4.31	.458
365.7	107.27	5467.2	611.7	7.14	.175	2003.9	235.8	4.32	.455
373.0	109.40	5638.1	626.5	7.18	.175	2055.1	241.8	4.33	.452
380.2	111.52	5811.5	641.3	7.22	.174	2106.3	247.8	4.35	.450
387.4	113.65	5987.2	656.1	7.26	.173	2157.5	253.8	4.36	.448
394.6	115.77	6165.4	671.1	7.30	.173	2208.6	259.8	4.37	.446
401.9	117.90	6345.9	686.0	7.34	.172	2259.8	265.9	4.38	.443
409.1	120.02	6529.0	701.1	7.38	.171	2311.0	271.9	4.39	.441
416.3	122.15	6714.5	716.2	7.41	.171	2362.2	277.9	4.40	.440
424.4	124.52	6832.6	733.7	7.41	.170	2655.6	295.1	4.62	.422
432.0	126.77	7029.0	749.8	7.45	.169	2716.4	301.8	4.63	.420
439.7	129.02	7228.1	765.9	7.48	.169	2777.1	308.6	4.64	.418
447.3	131.27	7429.8	782.1	7.52	.168	2837.9	315.3	4.65	.416
455.0	133.52	7634.2	798.3	7.56	.167	2898.6	322.1	4.66	.415
462.6	135.77	7841.3	814.7	7.60	.167	2959.4	328.8	4.67	.413
470.3	138.02	8051.1	831.1	7.64	.166	3020.1	335.6	4.68	.411
477.9	140.27	8263.6	847.6	7.68	.166	3080.9	342.3	4.69	.410
485.6	142.52	8478.9	864.1	7.71	.165	3141.6	349.1	4.70	.408
493.2	144.77	8696.9	880.7	7.75	.164	3202.4	355.8	4.70	.407
500.9	147.02	8917.7	897.4	7.79	.164	3263.1	362.6	4.71	.406

EXPLANATION OF TABLES OF SAFE LOADS UNIFORMLY DISTRIBUTED FOR BETHLEHEM GIRDER BEAMS AND BETHLEHEM I BEAMS.

Beams Laterally Supported. The tables on pages 77 to 91 give the safe uniformly distributed loads for Bethlehem Girder Beams and Bethlehem I Beams, based upon a maximum fiber stress of 18,000 pounds per square inch.

The tabular loads include the weights of the beams which should be deducted to obtain the net live loads for the beams.

On pages 125 to 135 are shown a series of end connection angles for Bethlehem Girder Beams and I Beams. The data given include the safe reactions, and corresponding minimum spans, of uniformly loaded beams as governed by the strengths of these connections.

Further data relating to minimum spans dependent on the strengths of these connections are given on pages 136 to 139.

If the load is concentrated at the center of the span, the safe live load is one-half the safe uniformly distributed live load for the same span.

The safe loads on short spans may be limited by the shearing or buckling strength of the web, instead of by the maximum bending stress allowed in the flanges. This limit is indicated in the tables by heavy cross lines, and the loads printed in smaller type above these lines are not based on stresses in the extreme fibers of the flanges due to flexure, nor are they proportional to the Section Moduli as are the loads below these lines. The loads above the heavy lines are the maximum safe uniformly distributed loads for web crippling, based on the formula given on page 94, with a maximum shearing stress of 12,000 pounds per square inch. The maximum safe shears based on the buckling strength of the webs, and the corresponding least spans for which the beams may be used when carrying full uniformly distributed loads, are given on pages 95 and 96.

Beams Laterally Unsupported. The safe loads of the tables on pages 77 to 91 are calculated upon the assumption that the compression flanges of the beams are properly secured against yielding sideways. In order to prevent undue strains in the compression flanges, considered as columns, the beams should be held laterally by tie rods, or other means, at intervals not greater than 15 times the widths of their flanges.

The Maximum Laterally Unsupported Lengths of Bethlehem Girder Beams Carrying Full Tabular Load are given on page 84, and of Bethlehem I Beams on page 92.

When the distance between lateral supports, l, in inches, exceeds 15 times the flange width, B, in inches, the tabular safe loads must be reduced.

The formula for the allowable unit stress, f, in the compression flange of a beam,

$$f = \frac{20{,}000}{1 + \frac{l^2}{2{,}000\ B^2}}$$

is a modification of the column formula given on page 97.

The table below gives the allowable unit stresses, f, and the ratios of the allowable safe load to the tabular safe load, for various values of $\frac{l}{B}$, based on the above formula.

ALLOWABLE FIBER STRESS AND PROPORTION OF SAFE LOADS FOR BEAMS UNSUPPORTED LATERALLY.

Ratio of Laterally Unsupported Length to Flange Width. $\frac{l}{B}$	Allowable Fiber Stress, Pounds per Square Inch. f	Ratio of Allowable Safe Load to Tabular Safe Load.	Ratio of Laterally Unsupported Length to Flange Width. $\frac{l}{B}$	Allowable Fiber Stress, Pounds per Square Inch. f	Ratio of Allowable Safe Load to Tabular Safe Load.
15	18,000	1.000	28	14,368	.798
16	17,730	.985	29	14,080	.782
17	17,475	.971	30	13,793	.766
18	17,212	.956	31	13,509	.751
19	16,942	.941	32	13,228	.735
20	16,667	.926	33	12,949	.719
21	16,387	.910	34	12,674	.704
22	16,103	.895	35	12,403	.689
23	15,817	.879	36	12,136	.674
24	15,528	.863	37	11,873	.660
25	15,238	.847	38	11,614	.645
26	14,948	.830	39	11,360	.631
27	14,657	.814	40	11,111	.617

Deflection. The vertical deflection, in inches, at the center of a beam carrying its full tabular safe uniformly distributed load, can be readily obtained from the Coefficients of Deflection, H and H′, given in the table on page 165, by dividing the coefficient for the given span by the depth of the beam, in inches. Deflections and data for other cases of loading are given on pages 166 to 168, inclusive.

The vertical deflection of beams carrying plastered ceilings should not exceed 1/360 of the distance between supports, or 1/30 of an inch per foot of span, in order to keep the plaster from cracking. This limit of span, L′, in feet, is approximately 1.8 times the depth, D, of the beam in inches for an extreme fiber stress of 18,000 pounds per square inch, and is indicated in the tables by dotted cross lines.

For spans exceeding this limit, it should be remembered that the plaster is applied when the beam is carrying a part of the total load, W, and only the deflection due to additional loading may cause the plaster to crack. This additional load, W′, in thousands of pounds, is given by the formula:—

$$W' = \frac{L'}{L} W$$

where,

L' = Limiting span, in feet, for maximum deflection.
L = Given span, in feet.
W = Tabular safe load given for the span L.
W' = That part of total load, W, which may be placed on the beam after the plastering of the ceiling is completed.

Impact. The safe loads given in the tables are static or quiescent loads. Loads applied suddenly, or moving loads, produce greater stresses.

An approximate formula to determine the effect of a falling load is given on page 163.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM GIRDER BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G30			G28		G26		
	30⅛″	30″	29⅞″	28⅛″	28″	26⅛″	26″	25⅞″
	200 Lbs.	190 Lbs.	181 Lbs.	175 Lbs.	165 Lbs.	160 Lbs.	151 Lbs.	144 Lbs.
						336.5	303.5	286.5
16	434.7			370.7	335.3	320.3	302.1	285.8
17	428.8	396.8	368.3	350.9	331.6	301.4	284.4	268.9
18	405.0	384.5	365.1	331.4	313.2	284.7	268.6	254.0
19	383.7	364.3	345.8	313.9	296.7	269.7	254.4	240.6
20	364.5	346.1	328.6	298.3	281.9	256.2	241.7	228.6
21	347.1	329.6	312.9	284.0	268.5	244.0	230.2	217.7
22	331.4	314.6	298.7	271.1	256.3	232.9	219.7	207.8
23	317.0	300.9	285.7	259.3	245.1	222.8	210.2	198.8
24	303.8	288.4	273.8	248.5	234.9	213.5	201.4	190.5
25	291.6	276.8	262.8	238.6	225.5	205.0	193.4	182.9
26	280.4	266.2	252.7	229.4	216.8	197.1	185.9	175.8
27	270.0	256.3	243.4	220.9	208.8	189.8	179.0	169.3
28	260.4	247.2	234.7	213.0	201.4	183.0	172.6	163.3
29	251.4	238.7	226.6	205.7	194.4	176.7	166.7	157.7
30	243.0	230.7	219.0	198.8	187.9	170.8	161.1	152.4
31	235.2	223.3	212.0	192.4	181.9	165.3	155.9	147.5
32	227.8	216.3	205.3	186.4	176.2	160.1	151.1	142.9
33	220.9	209.7	199.1	180.8	170.8	155.3	146.5	138.5
34	214.4	203.6	193.3	175.4	165.8	150.7	142.2	134.5
35	208.3	197.7	187.7	170.4	161.1	146.4	138.1	130.6
36	202.5	192.3	182.5	165.7	156.6	142.3	134.3	127.0
37	197.0	187.1	177.6	161.2	152.4	138.5	130.6	123.6
38	191.8	182.1	172.9	157.0	148.4	134.8	127.2	120.3
39	186.9	177.5	168.5	152.9	144.6	131.4	123.9	117.2
40	182.3	173.0	164.3	149.1	141.0	128.1	120.9	114.3
41	177.8	168.8	160.3	145.5	137.5	125.0	117.9	111.5
42	173.6	164.8	156.5	142.0	134.2	122.0	115.1	108.9
43	169.5	161.0	152.8	138.7	131.1	119.2	112.4	106.3
44	165.7	157.3	149.3	135.6	128.1	116.5	109.9	103.9
45	162.0	153.8	146.0	132.6	125.3	113.9	107.4	101.6
46	158.5	150.5	142.8	129.7	122.6	111.4	105.1	99.4
47	155.1	147.3	139.8	126.9	120.0	109.0	102.9	97.3
48	151.9	144.2	136.9	124.3	117.5	106.8	100.7	95.3
49	148.8	141.2	134.1	121.7	115.1	104.6	98.7	93.3
50	145.8	138.4	131.4	119.3	112.8	102.5	96.7	91.4

Safe loads given include weight of beam.
Maximum fiber stress, 18,000 pounds per square inch.
Greatest safe loads limited by web shear or buckling are given above the heavy line.
Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM GIRDER BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G24a			G24		
	24⅛″	24″	23⅞″	24⅛″	24″	23⅞″
	149 Lbs.	141 Lbs.	133 Lbs.	129 Lbs.	121 Lbs.	114 Lbs.
	311.1	280.4		258.3		
15	295.3	278.3	257.3	255.1	228.2	
16	276.8	260.9	245.8	239.1	224.1	205.8
17	260.5	245.5	231.3	225.1	210.9	197.5
18	246.1	231.9	218.4	212.6	199.2	186.5
19	233.1	219.7	206.9	201.4	188.7	176.7
20	221.5	208.7	196.6	191.3	179.3	167.9
21	210.9	198.8	187.2	182.2	170.7	159.9
22	201.3	189.7	178.7	173.9	163.0	152.6
23	192.6	181.5	171.0	166.3	155.9	146.0
24	184.5	173.9	163.8	159.4	149.4	139.9
25	177.2	167.0	157.3	153.0	143.4	134.3
26	170.3	160.5	151.2	147.2	137.9	129.1
27	164.0	154.6	145.6	141.7	132.8	124.3
28	158.2	149.1	140.4	136.6	128.0	119.9
29	152.7	143.9	135.6	131.9	123.6	115.8
30	147.6	139.1	131.1	127.5.	119.5	111.9
31	142.9	134.6	126.8	123.4	115.6	108.3
32	138.4	130.4	122.9	119.6	112.0	104.9
33	134.2	126.5	119.2	115.9	108.6	101.7
34	130.3	122.8	115.6	112.5	105.4	98.7
35	126.5	119.3	112.3	109.3	102.4	95.9
36	123.0	115.9	109.2	106.3	99.6	93.3
37	119.7	112.8	106.3	103.4	96.9	90.7
38	116.6	109.8	103.5	100.7	94.3	88.3
39	113.6	107.0	100.8	98.1	91.9	86.1
40	110.7	104.4	98.3	95.7	89.6	83.9
41	108.0	101.8	95.9	93.3	87.4	81.9
42	105.5	99.4	93.6	91.1	85.4	79.9
43	103.0	97.1	91.4	89.0	83.4	78.1
44	100.7	94.9	89.4	87.0	81.5	76.3
45	98.4	92.8	87.4	85.0	79.7	74.6

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM GIRDER BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G20a			G20		
	20⅛″	20″	19⅞″	20⅛″	20″	19⅞″
	149 Lbs.	142 Lbs.	135 Lbs.	120 Lbs.	113 Lbs.	107 Lbs.
	310.7					
12	308.8	290.8	271.1	247.1	227.3	213.9
13	285.1	270.7	256.4	229.9	216.0	202.8
14	264.7	251.4	238.1	213.5	200.6	188.4
15	247.1	234.6	222.2	199.3	187.2	175.8
16	231.6	219.9	208.3	186.8	175.5	164.8
17	218.0	207.0	196.1	175.8	165.2	155.1
18	205.9	195.5	185.2	166.1	156.0	146.5
19	195.1	185.2	175.4	157.3	147.8	138.8
20	185.3	176.0	166.7	149.5	140.4	131.9
21	176.5	167.6	158.7	142.3	133.7	125.6
22	168.5	160.0	151.5	135.9	127.6	119.9
23	161.1	153.0	144.9	130.0	122.1	114.7
24	154.4	146.6	138.9	124.5	117.0	109.9
25	148.2	140.8	133.3	119.6	112.3	105.5
26	142.5	135.3	128.2	115.0	108.0	101.4
27	137.3	130.3	123.4	110.7	104.0	97.7
28	132.4	125.7	119.0	106.8	100.3	94.2
29	127.8	121.3	114.9	103.1	96.8	90.9
30	123.5	117.3	111.1	99.6	93.6	87.9
31	119.5	113.5	107.5	96.4	90.6	85.1
32	115.8	110.0	104.2	93.4	87.8	82.4
33	112.3	106.6	101.0	90.6	85.1	79.9
34	109.0	103.5	98.0	87.9	82.6	77.6
35	105.9	100.5	95.2	85.4	80.2	75.3
36	102.9	97.8	92.6	83.0	78.0	73.3
37	100.2	95.1	90.1	80.8	75.9	71.3
38	97.5	92.6	87.7	78.7	73.9	69.4
39	95.0	90.2	85.5	76.6	72.0	67.6
40	92.7	88.0	83.3	74.7	70.2	65.9

Safe loads given include weight of beam.
Maximum fiber stress, 18,000 pounds per square inch.
Greatest safe loads limited by web shear or buckling are given above the heavy line.
Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM GIRDER BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G18			G15b		
	18⅛"	18"	17⅞"	15⅛"	15"	14⅞"
	100 Lbs.	93 Lbs.	87.5 Lbs.	147 Lbs.	141 Lbs.	135 Lbs.
				301.3	288.0	275.0
9				293.9	280.4	267.1
10				264.5	252.4	240.4
11	194.2			240.5	229.5	218.5
12	190.5	171.0	159.0	220.4	210.3	200.3
13	175.8	163.5	152.1	203.5	194.2	184.9
14	163.3	151.8	141.2	188.9	180.3	171.7
15	152.4	141.7	131.8	176.3	168.3	160.3
16	142.9	132.8	123.6	165.3	157.8	150.3
17	134.5	125.0	116.3	155.6	148.5	141.4
18	127.0	118.1	109.8	146.9	140.2	133.6
19	120.3	111.8	104.1	139.2	132.8	126.5
20	114.3	106.3	98.9	132.3	126.2	120.2
21	108.9	101.2	94.1	126.0	120.2	114.5
22	103.9	96.6	89.9	120.2	114.7	109.3
23	99.4	92.4	86.0	115.0	109.7	104.5
24	95.3	88.5	82.4	110.2	105.2	100.2
25	91.4	85.0	79.1	105.8	101.0	96.2
26	87.9	81.7	76.0	101.7	97.1	92.5
27	84.7	78.7	73.2	98.0	93.5	89.0
28	81.6	75.9	70.6	94.5	90.1	85.9
29	78.8	73.3	68.2	91.2	87.0	82.9
30	76.2	70.8	65.9	88.2	84.1	80.1
31	73.7	68.5	63.8	85.3	81.4	77.5
32	71.4	66.4	61.8	82.7	78.9	75.1
33	69.3	64.4	59.9	80.2	76.5	72.8
34	67.2	62.5	58.1	77.8	74.2	70.7
35	65.3	60.7	56.5	75.6	72.1	68.7
36	63.5	59.0	54.9			
37	61.8	57.4	53.4			
38	60.2	55.9	52.0			
39	58.6	54.5	50.7			
40	57.2	53.1	49.4			

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR
BETHLEHEM GIRDER BEAMS,
IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G15a			G15		
	15⅛"	15"	14⅞"	15⅛"	15"	14⅞"
	111 Lbs.	105 Lbs.	99 Lbs.	80.5 Lbs.	74 Lbs.	69 Lbs.
	231.6					
9	230.4	212.1	197.1	156.9		
10	207.4	194.9	183.0	153.7		
					137.5	127.3
11	188.5	177.2	166.4	139.7	128.5	118.3
12	172.8	162.4	152.5	128.1	117.8	108.4
13	159.5	149.9	140.8	118.2	108.8	100.1
14	148.1	139.2	130.7	109.8	101.0	92.9
15	138.3	129.9	122.0	102.5	94.3	86.7
16	129.6	121.8	114.4	96.1	88.4	81.3
17	122.0	114.6	107.6	90.4	83.2	76.5
18	115.2	108.3	101.7	85.4	78.6	72.3
19	109.2	102.6	96.3	80.9	74.4	68.5
20	103.7	97.5	91.5	76.9	70.7	65.1
21	98.8	92.8	87.1	73.2	67.3	62.0
22	94.3	88.6	83.2	69.9	64.3	59.1
23	90.2	84.7	79.6	66.8	61.5	56.6
24	86.4	81.2	76.3	64.0	58.9	54.2
25	83.0	78.0	73.2	61.5	56.6	52.0
26	79.8	75.0	70.4	59.1	54.4	50.0
27	76.8	72.2	67.8	56.9	52.4	48.2
28	74.1	69.6	65.4	54.9	50.5	46.5
29	71.5	67.2	63.1	53.0	48.8	44.9
30	69.1	65.0	61.0	51.2	47.1	43.4
31	66.9	62.9	59.0	49.6	45.6	42.0
32	64.8	60.9	57.2	48.0	44.2	40.7
33	62.8	59.1	55.5	46.6	42.8	39.4
34	61.0	57.3	53.8	45.2	41.6	38.3
35	59.3	55.7	52.3	43.9	40.4	37.2

Safe loads given include weight of beam.
Maximum fiber stress, 18,000 pounds per square inch.
Greatest safe loads limited by web shear or buckling are given above the heavy line.
Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR
BETHLEHEM GIRDER BEAMS,
IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G12a			G12		
	12⅛"	12"	11⅞"	12⅛"	12"	11$\frac{29}{32}$"
	76.5 Lbs.	70.5 Lbs.	66 Lbs.	61 Lbs.	55.5 Lbs.	51.5 Lbs.
	147.7					
8	145.8	132.1	123.7	110.5	98.6	90.6
9	129.6	119.7	110.4	105.6	96.0	88.9
10	116.6	107.7	99.3	95.0	86.4	80.0
11	106.0	97.9	90.3	86.4	78.5	72.7
12	97.2	89.7	82.8	79.2	72.0	66.6
13	89.7	82.8	76.4	73.1	66.4	61.5
14	83.3	76.9	71.0	67.9	61.7	57.1
15	77.7	71.8	66.2	63.4	57.6	53.3
16	72.9	67.3	62.1	59.4	54.0	50.0
17	68.6	63.4	58.4	55.9	50.8	47.0
18	64.8	59.8	55.2	52.8	48.0	44.4
19	61.4	56.7	52.3	50.0	45.5	42.1
20	58.3	53.9	49.7	47.5	43.2	40.0
21	55.5	51.3	47.3	45.3	41.1	38.1
22	53.0	49.0	45.2	43.2	39.3	36.4
23	50.7	46.8	43.2	41.3	37.5	34.8
24	48.6	44.9	41.4	39.6	36.0	33.3
25	46.6	43.1	39.7	38.0	34.5	32.0
26	44.8	41.4	38.2	36.6	33.2	30.8
27	43.2	39.9	36.8	35.2	32.0	29.6
28	41.6	38.5	35.5	33.9	30.8	28.6
29	40.2	37.1	34.3	32.8	29.8	27.6
30	38.9	35.9	33.1	31.7	28.8	26.7

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM GIRDER BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	G10			G9			G8		
	10⅛"	10"	9²⁹⁄₃₂"	9⅛"	9"	8¹⁵⁄₁₆"	8⅛"	8"	7¹⁵⁄₁₆"
	50 Lbs.	44.5 Lbs.	41.5 Lbs.	43.5 Lbs.	38.5 Lbs.	36 Lbs.	37 Lbs.	33 Lbs.	31 Lbs.
				74.4			63.5	55.5	52.7
7	83.0			72.9	62.7	56.9	55.4	48.9	45.8
8	81.7	69.9	66.3	63.8	56.8	53.3	48.5	42.8	40.1
9	72.6	65.3	60.2	56.7	50.5	47.4	43.1	38.1	35.7
10	65.3	58.7	54.2	51.0	45.4	42.7	38.8	34.3	32.1
11	59.4	53.4	49.3	46.4	41.3	38.8	35.2	31.1	29.2
12	54.4	48.9	45.2	42.5	37.9	35.6	32.3	28.6	26.7
13	50.3	45.2	41.7	39.2	34.9	32.8	29.8	26.4	24.7
14	46.7	42.0	38.7	36.4	32.5	30.5	27.7	24.5	22.9
15	43.6	39.2	36.1	34.0	30.3	28.4	25.8	22.8	21.4
16	40.8	36.7	33.9	31.9	28.4	26.7	24.2	21.4	20.1
17	38.4	34.5	31.9	30.0	26.7	25.1	22.8	20.2	18.9
18	36.3	32.6	30.1	28.3	25.2	23.7	21.5	19.0	17.8
19	34.4	30.9	28.5	26.8	23.9	22.5	20.4	18.0	16.9
20	32.7	29.4	27.1	25.5	22.7	21.3	19.4	17.1	16.0
21	31.1	28.0	25.8	24.3	21.6	20.3			
22	29.7	26.7	24.6	23.2	20.7	19.4			
23	28.4	25.5	23.6	22.2	19.8	18.5			
24	27.2	24.5	22.6	21.3	18.9	17.8			
25	26.1	23.5	21.7	20.4	18.2	17.1			

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS FOR

BETHLEHEM GIRDER BEAMS

LATERALLY UNSUPPORTED.

The safe loads on Bethlehem Girder Beams given on pages 77 to 83, inclusive, are calculated upon the assumption that the compression flanges of the beams are properly secured against yielding sideways.

When the distance between lateral supports exceeds 15 times the flange width, the tabular safe loads must be reduced as explained on page 75.

MAXIMUM LATERALLY UNSUPPORTED LENGTHS OF BETHLEHEM GIRDER BEAMS CARRYING FULL TABULAR LOAD.

UNSUPPORTED LENGTH OF COMPRESSION FLANGE = 15 FLANGE WIDTHS.

Section Number.	Weight per Foot, Pounds.	Laterally Unsupported Length, Feet.	Section Number.	Weight per Foot, Pounds.	Laterally Unsupported Length, Feet.
G30	200.0	18.8	G15b	147.0	14.7
	190.0	18.8		141.0	14.7
	181.0	18.7		135.0	14.7
G28	175.0	17.9	G15a	111.0	14.1
	165.0	17.8		105.0	14.1
				99.0	14.0
G26	160.0	17.2	G15	80.5	13.5
	151.0	17.2		74.0	13.4
	144.0	17.2		69.0	13.4
G24a	149.0	16.6	G12a	76.5	12.9
	141.0	16.6		70.5	12.8
	133.0	16.5		66.0	12.8
G24	129.0	15.4	G12	61.0	12.5
	121.0	15.3		55.5	12.5
	114.0	15.3		51.5	12.5
G20a	149.0	16.0	G10	50.0	11.3
	142.0	15.9		44.5	11.3
	135.0	15.9		41.5	11.2
G20	120.0	15.0	G9	43.5	10.7
	113.0	15.0		38.5	10.6
	107.0	15.0		36.0	10.6
G18	100.0	14.4	G8	37.0	10.0
	93.0	14.4		33.0	10.0
	87.5	14.4		31.0	10.0

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B30			B28		
	30⅛″	30″	29⅞″	28⅛″	28″	27⅞″
	129 Lbs.	121 Lbs.	115 Lbs.	113 Lbs.	106 Lbs.	100 Lbs.
				232.5		
16	268.1			228.6	207.7	191.3
17	260.9	241.5	223.8	215.2	201.4	188.5
18	246.4	231.7	218.1	203.2	190.2	178.1
19	233.4	219.5	206.6	192.5	180.2	168.7
20	221.8	208.6	196.3	182.9	171.2	160.3
21	211.2	198.6	186.9	174.2	163.0	152.6
22	201.6	189.6	178.4	166.3	155.6	145.7
23	192.8	181.3	170.7	159.0	148.8	139.3
24	184.8	173.8	163.5	152.4	142.6	133.5
25	177.4	166.8	157.0	146.3	136.9	128.2
26	170.6	160.4	151.0	140.7	131.7	123.3
27	164.3	154.5	145.4	135.5	126.8	118.7
28	158.4	149.0	140.2	130.6	122.3	114.5
29	152.9	143.8	135.3	126.1	118.0	110.5
30	147.8	139.0	130.8	121.9	114.1	106.8
31	143.1	134.5	126.6	118.0	110.4	103.4
32	138.6	130.3	122.7	114.3	107.0	100.2
33	134.4	126.4	118.9	110.8	103.7	97.1
34	130.4	122.7	115.4	107.6	100.7	94.3
35	126.7	119.2	112.1	104.5	97.8	91.6
36	123.2	115.9	109.0	101.6	95.1	89.0
37	119.9	112.7	106.1	98.9	92.5	86.6
38	116.7	109.8	103.3	96.3	90.1	84.3
39	113.7	106.9	100.6	93.8	87.8	82.2
40	110.9	104.3	98.1	91.5	85.6	80.1
41	108.2	101.7	95.7	89.2	83.5	78.2
42	105.6	99.3	93.5	87.1	81.5	76.3
43	103.1	97.0	91.3	85.1	79.6	74.5
44	100.8	94.8	89.2	83.1	77.8	72.8
45	98.6	92.7	87.2	81.3	76.1	71.2
46	96.4	90.7	85.3	79.5	74.4	69.7
47	94.4	88.7	83.5	77.8	72.8	68.2
48	92.4	86.9	81.8	76.2	71.3	66.8
49	90.5	85.1	80.1	74.7	69.9	65.4
50	88.7	83.4	78.5	73.2	68.5	64.1

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B26			B24b		
	26⅛″	26″	25⅞″	$24\frac{3}{32}$″	24″	$23\frac{29}{32}$″
	98 Lbs.	91 Lbs.	85.5 Lbs.	104.5 Lbs.	99.5 Lbs.	95.5 Lbs.
				234.6		
13				227.5	215.9	201.0
14	199.1			211.2	200.9	190.9
15	196.1	176.3	161.2	197.1	187.5	178.2
16	183.8	170.9	158.9	184.8	175.8	167.1
17	173.0	160.9	149.6	173.9	165.4	157.2
18	163.4	151.9	141.3	164.3	156.2	148.5
19	154.8	143.9	133.8	155.6	148.0	140.7
20	147.1	136.8	127.2	147.9	140.6	133.7
21	140.0	130.2	121.1	140.8	133.9	127.3
22	133.7	124.3	115.6	134.4	127.8	121.5
23	127.9	118.9	110.6	128.6	122.3	116.2
24	122.5	114.0	106.0	123.2	117.2	111.4
25	117.6	109.4	101.7	118.3	112.5	106.9
26	113.1	105.2	97.8	113.7	108.2	102.8
27	108.9	101.3	94.2	109.5	104.1	99.0
28	105.0	97.7	90.8	105.6	100.4	95.5
29	101.4	94.3	87.7	102.0	97.0	92.2
30	98.0	91.2	84.8	98.6	93.7	89.1
31	94.9	88.2	82.0	95.4	90.7	86.2
32	91.9	85.5	79.5	92.4	87.9	83.5
33	89.1	82.9	77.1	89.6	85.2	81.0
34	86.5	80.4	74.8	87.0	82.7	78.6
35	84.0	78.1	72.7	84.5	80.3	76.4
36	81.7	76.0	70.6	82.1	78.1	74.3
37	79.5	73.9	68.7	79.9	76.0	72.2
38	77.4	72.0	66.9	77.8	74.0	70.3
39	75.4	70.1	65.2	75.8	72.1	68.5
40	73.5	68.4	63.6	73.9	70.3	66.8
41	71.7	66.7	62.0	72.1	68.6	65.2
42	70.0	65.1	60.5	70.4	67.0	63.6
43	68.4	63.6	59.1	68.8	65.4	62.2
44	66.8	62.2	57.8	67.2	63.9	60.8
45	65.4	60.8	56.5	65.7	62.5	59.4
46	63.9	59.5	55.3	64.3	61.1	58.1
47	62.6	58.2	54.1	62.9	59.8	56.9

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B24a	B24		B22		
	24″	24 3/32″	24″	22 1/8″	22 1/16″	22″
	84.5 Lbs.	79.5 Lbs.	73.5 Lbs.	71.5 Lbs.	68.5 Lbs.	65.5 Lbs.
				140.7	131.0	
14	168.4			132.1	126.6	118.4
15	158.7	147.8		123.3	118.2	112.7
16	148.8	139.8	124.4	115.6	110.8	105.6
17	140.0	131.6	122.8	108.8	104.3	99.4
18	132.2	124.3	115.9	102.8	98.5	93.9
19	125.3	117.7	109.8	97.4	93.3	88.9
20	119.0	111.9	104.4	92.5	88.7	84.5
21	113.3	106.5	99.4	88.1	84.4	80.5
22	108.2	101.7	94.9	84.1	80.6	76.8
23	103.5	97.3	90.7	80.4	77.1	73.5
24	99.2	93.2	87.0	77.1	73.9	70.4
25	95.2	89.5	83.5	74.0	70.9	67.6
26	91.5	86.0	80.3	71.2	68.2	65.0
27	88.1	82.9	77.3	68.5	65.7	62.6
28	85.0	79.9	74.5	66.1	63.3	60.4
29	82.1	77.1	72.0	63.8	61.1	58.3
30	79.3	74.6	69.6	61.7	59.1	56.3
31	76.8	72.2	67.3	59.7	57.2	54.5
32	74.4	69.9	65.2	57.8	55.4	52.8
33	72.1	67.8	63.2	56.1	53.7	51.2
34	70.0	65.8	61.4	54.4	52.1	49.7
35	68.0	63.9	59.6	52.9	50.7	48.3
36	66.1	62.1	58.0	51.4	49.3	46.9
37	64.3	60.5	56.4	50.0	47.9	45.7
38	62.6	58.9	54.9	48.7	46.7	44.5
39	61.0	57.4	53.5	47.4	45.5	43.3
40	59.5	55.9	52.2	46.3	44.3	42.3
41	58.0	54.6	50.9	45.1	43.2	41.2
42	56.7	53.3	49.7	44.0	42.2	40.2
43	55.3	52.0	48.5	43.0	41.2	39.3
44	54.1	50.8	47.4	42.0	40.3	38.4
45	52.9	49.7	46.4	41.1	39.4	37.6
46	51.7	48.6	45.4			
47	50.6	47.6	44.4			

Safe loads given include weight of beam.
Maximum fiber stress, 18,000 pounds per square inch.
Greatest safe loads limited by web shear or buckling are given above the heavy line.
Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B20a		B20		
	20 3/32″	20″	20 1/8″	20 1/16″	20″
	78 Lbs.	73 Lbs.	64.5 Lbs.	62 Lbs.	59.5 Lbs.
11	164.4				
12	156.2	145.8	127.5	121.3	112.4
13	144.2	135.5	117.8	113.0	108.0
14	133.9	125.8	109.4	104.9	100.3
15	124.9	117.4	102.1	97.9	93.6
16	117.1	110.1	95.7	91.8	87.8
17	110.2	103.6	90.1	86.4	82.6
18	104.1	97.8	85.1	81.6	78.0
19	98.6	92.7	80.6	77.3	73.9
20	93.7	88.1	76.6	73.5	70.2
21	89.2	83.9	72.9	70.0	66.9
22	85.2	80.0	69.6	66.8	63.8
23	81.5	76.6	66.6	63.9	61.0
24	78.1	73.4	63.8	61.2	58.5
25	75.0	70.4	61.2	58.8	56.2
26	72.1	67.7	58.9	56.5	54.0
27	69.4	65.2	56.7	54.4	52.0
28	66.9	62.9	54.7	52.5	50.1
29	64.6	60.7	52.8	50.7	48.4
30	62.5	58.7	51.0	49.0	46.8
31	60.5	56.8	49.4	47.4	45.3
32	58.6	55.0	47.8	45.9	43.9
33	56.8	53.4	46.4	44.5	42.5
34	55.1	51.8	45.0	43.2	41.3
35	53.5	50.3	43.7	42.0	40.1
36	52.1	48.9	42.5	40.8	39.0
37	50.6	47.6	41.4	39.7	37.9
38	49.3	46.3	40.3	38.7	36.9
39	48.1	45.2	39.3	37.7	36.0
40	46.9	44.0	38.3	36.7	35.1

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B18a			B18		
	18⅛″	18″	17⅞″	18⅛″	18$\frac{1}{16}$″	18″
	74 Lbs.	69 Lbs.	64.5 Lbs.	54.5 Lbs.	52 Lbs.	49 Lbs.
				108.7		
11	148.7	136.8	125.2	107.0	100.5	
12	136.7	126.9	117.3	98.1	93.5	87.3
13	126.2	117.2	108.2	90.5	86.3	81.5
14	117.1	108.8	100.5	84.1	80.1	75.7
15	109.3	101.5	93.8	78.5	74.8	70.7
16	102.5	95.2	87.9	73.6	70.1	66.3
17	96.5	89.6	82.8	69.2	66.0	62.4
18	91.1	84.6	78.2	65.4	62.3	58.9
19	86.3	80.2	74.1	61.9	59.1	55.8
20	82.0	76.2	70.4	58.9	56.1	53.0
21	78.1	72.5	67.0	56.0	53.4	50.5
22	74.5	69.2	64.0	53.5	51.0	48.2
23	71.3	66.2	61.2	51.2	48.8	46.1
24	68.3	63.5	58.6	49.0	46.8	44.2
25	65.6	60.9	56.3	47.1	44.9	42.4
26	63.1	58.6	54.1	45.3	43.2	40.8
27	60.7	56.4	52.1	43.6	41.6	39.3
28	58.6	54.4	50.3	42.0	40.1	37.9
29	56.6	52.5	48.5	40.6	38.7	36.6
30	54.7	50.8	46.9	39.2	37.4	35.3
31	52.9	49.1	45.4	38.0	36.2	34.2
32	51.3	47.6	44.0	36.8	35.1	33.1
33	49.7	46.2	42.6	35.7	34.0	32.1
34	48.2	44.8	41.4	34.6	33.0	31.2
35	46.9	43.5	40.2	33.6	32.1	30.3
36	45.6	42.3	39.1	32.7	31.2	29.4
37	44.3	41.2	38.0	31.8	30.3	28.6
38	43.2	40.1	37.0	31.0	29.5	27.9
39	42.1	39.1	36.1	30.2	28.8	27.2
40	41.0	38.1	35.2	29.4	28.1	26.5

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B15b	B15a			B15		
	15″	15⅛″	15″	14⅞″	15$\frac{3}{32}$″	15$\frac{1}{32}$″	15″
	71.5 Lbs.	59.5 Lbs.	54.5 Lbs.	50.5 Lbs.	42.5 Lbs.	40 Lbs.	38.5 Lbs.
	175.0	142.5	123.2				
8	157.9	132.6	121.9	110.9			
9	140.3	117.9	108.4	99.6	83.3	74.2	
10	126.3	106.1	97.5	89.6	77.4	73.2	
							67.5
11	114.8	96.5	88.7	81.5	70.4	66.5	64.4
12	105.3	88.4	81.3	74.7	64.5	61.0	59.0
13	97.2	81.6	75.0	69.0	59.6	56.3	54.5
14	90.2	75.8	69.7	64.0	55.3	52.3	50.6
15	84.2	70.7	65.0	59.8	51.6	48.8	47.2
16	78.9	66.3	61.0	56.0	48.4	45.7	44.2
17	74.3	62.4	57.4	52.7	45.5	43.0	41.6
18	70.2	58.9	54.2	49.8	43.0	40.6	39.3
19	66.5	55.8	51.3	47.2	40.8	38.5	37.3
20	63.2	53.1	48.8	44.8	38.7	36.6	35.4
21	60.1	50.5	46.4	42.7	36.9	34.8	33.7
22	57.4	48.2	44.3	40.7	35.2	33.3	32.2
23	54.9	46.1	42.4	39.0	33.7	31.8	30.8
24	52.6	44.2	40.6	37.4	32.3	30.5	29.5
25	50.5	42.4	39.0	35.9	31.0	29.3	28.3
26	48.6	40.8	37.5	34.5	29.8	28.1	27.2
27	46.8	39.3	36.1	33.2	28.7	27.1	26.2
28	45.1	37.9	34.8	32.0	27.7	26.1	25.3
29	43.6	36.6	33.6	30.9	26.7	25.2	24.4
30	42.1	35.4	32.5	29.9	25.8	24.4	23.6
31	40.7	34.2	31.5	28.9	25.0	23.6	22.8
32	39.5	33.2	30.5	28.0	24.2	22.9	22.1
33	38.3	32.2	29.6	27.2	23.5	22.2	21.5
34	37.1	31.2	28.7	26.4	22.8	21.5	20.8
35	36.1	30.3	27.9	25.6	22.1	20.9	20.2

Safe loads given include weight of beam.
Maximum fiber stress, 18,000 pounds per square inch.
Greatest safe loads limited by web shear or buckling are given above the heavy line.
Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS UNIFORMLY DISTRIBUTED FOR

BETHLEHEM I BEAMS,

IN THOUSANDS OF POUNDS.

BEAMS BEING SECURED AGAINST YIELDING SIDEWAYS.

Span in Feet.	B12a	B12		B10		B9		B8	
	12"	12 1/16"	12"	10 3/32"	10"	9 1/16"	9"	8 1/16"	8"
	36.5 Lbs.	31 Lbs.	28.5 Lbs.	26 Lbs.	23.5 Lbs.	22 Lbs.	20.5 Lbs.	19 Lbs.	17.5 Lbs.
								47.6	
4								46.8	42.4
5								37.4	34.2
						48.2	45.1		
6				53.8	47.2	41.0	38.0	31.2	28.5
7	72.2			46.4	41.8	35.1	32.6	26.7	24.4
8	67.3	57.2	49.8	40.6	36.6	30.8	28.5	23.4	21.4
9	59.8	51.4	48.0	36.1	32.5	27.3	25.3	20.8	19.0
10	53.9	46.2	43.2	32.5	29.3	24.6	22.8	18.7	17.1
11	49.0	42.0	39.2	29.6	26.6	22.4	20.7	17.0	15.5
12	44.9	38.5	36.0	27.1	24.4	20.5	19.0	15.6	14.2
13	41.4	35.6	33.2	25.0	22.5	18.9	17.5	14.4	13.1
14	38.5	33.0	30.8	23.2	20.9	17.6	16.3	13.4	12.2
15	35.9	30.8	28.8	21.7	19.5	16.4	15.2	12.5	11.4
16	33.7	28.9	27.0	20.3	18.3	15.4	14.3	11.7	10.7
17	31.7	27.2	25.4	19.1	17.2	14.5	13.4	11.0	10.0
18	29.9	25.7	24.0	18.1	16.3	13.7	12.7	10.4	9.5
19	28.3	24.3	22.7	17.1	15.4	12.9	12.0	9.9	9.0
20	26.9	23.1	21.6	16.3	14.6	12.3	11.4	9.4	8.5
21	25.6	22.0	20.6	15.5	13.9	11.7	10.9		
22	24.5	21.0	19.6	14.8	13.3	11.2	10.4		
23	23.4	20.1	18.8	14.1	12.7	10.7	9.9		
24	22.4	19.3	18.0	13.5	12.2	10.3	9.5		
25	21.5	18.5	17.3	13.0	11.7	9.8	9.1		
26	20.7	17.8	16.6						
27	19.9	17.1	16.0						
28	19.2	16.5	15.4						
29	18.6	15.9	14.9						
30	18.0	15.4	14.4						

Safe loads given include weight of beam.

Maximum fiber stress, 18,000 pounds per square inch.

Greatest safe loads limited by web shear or buckling are given above the heavy line.

Safe loads below the dotted line produce deflections exceeding $\frac{1}{360}$ of the span.

SAFE LOADS FOR

BETHLEHEM I BEAMS

LATERALLY UNSUPPORTED.

The safe loads on Bethlehem I Beams given on pages 85 to 91, inclusive, are calculated upon the assumption that the compression flanges of the beams are properly secured against yielding sideways.

When the distance between lateral supports exceeds 15 times the flange width, the tabular safe loads must be reduced as explained on page 75.

MAXIMUM LATERALLY UNSUPPORTED LENGTHS OF BETHLEHEM I BEAMS CARRYING FULL TABULAR LOAD.

UNSUPPORTED LENGTH OF COMPRESSION FLANGE = 15 FLANGE WIDTHS.

Section Number.	Weight per Foot, Pounds.	Laterally Unsupported Length, Feet.
B30	129.0	13.2
	121.0	13.1
	115.0	13.1
B28	113.0	12.5
	106.0	12.5
	100.0	12.5
B26	98.0	11.9
	91.0	11.9
	85.5	11.9
B24b	104.5	12.2
	99.5	12.2
	95.5	12.2
B24a	84.5	11.9
B24	79.5	11.3
	73.5	11.3
B22	71.5	10.7
	68.5	10.7
	65.5	10.6
B20a	78.0	11.1
	73.0	11.1
B20	64.5	10.0
	62.0	10.0
	59.5	10.0

Section Number.	Weight per Foot, Pounds.	Laterally Unsupported Length, Feet.
B18a	74.0	11.0
	69.0	10.9
	64.5	10.9
B18	54.5	9.4
	52.0	9.4
	49.0	9.4
B15b	71.5	9.4
B15a	59.5	8.8
	54.5	8.8
	50.5	8.7
B15	42.5	8.5
	40.0	8.5
	38.5	8.4
B12a	36.5	8.0
B12	31.0	7.8
	28.5	7.8
B10	26.0	7.2
	23.5	7.2
B9	22.0	6.9
	20.5	6.9
B8	19.0	6.6
	17.5	6.6

EXPLANATION OF TABLES OF

MAXIMUM SAFE SHEAR FOR BETHLEHEM GIRDER BEAMS AND I BEAMS AND CORRESPONDING MINIMUM SPANS.

On pages 95 and 96 are given Tables of Maximum Safe Shear for Bethlehem Girder and I Beams, based upon web buckling, and the corresponding minimum spans.

Beams and girders when used for short spans should be examined for safe strength of the web for buckling or crippling, due to the shearing stresses.

For uniformly distributed loads, one-half is transmitted through each end portion of the web, as shear, to deliver the load to the end supports.

In general, the Tables of Safe Loads for Bethlehem Girder Beams and I Beams herein are computed with regard to the safe unit stresses due to flexure, although a few cases of limitations due to web crippling, for short spans, are given at the tops of these tables in order to call attention to this feature.

The tables on pages 95 and 96 are, however, more comprehensive in this respect and, in addition to stating the maximum safe shear at each end, also give the minimum spans for which the beams will sustain their full uniform loads with due regard to flexure and web buckling.

The vertical shears for different systems of loading at any section of a simple beam may be obtained by determining the algebraic sum of all the external forces acting on one side or the other of the section.

The reactions at the supports of the beam are external forces, and are obtained for either point of support from the algebraic sum of the moments of all the loads about the other point of support, divided by the span length.

The shearing stresses in the web of a beam can be resolved into two component stresses of equal intensity, at right angles to each other, and at angles of 45 degrees with the Neutral Axis of the beam as a whole. These component stresses are equivalent to compressive and tensile forces acting upon the web of the beam. The compressive forces tend to buckle the web which, however, is not entirely free to buckle, because the tensile forces acting at right angles have the effect of stiffening it.

The following formula may be used to calculate the total safe buckling resistance, V, due to web shear:—

$$V = \frac{13{,}500\,Dt}{1 + \frac{h^2}{3000t^2}}$$

in which,

D = Depth of beam, inches.

t = Thickness of web, inches.

h = Clear distance between flanges, inches.

V = Total safe buckling resistance of web, pounds.

The safe buckling stress must never exceed the safe shearing stress. Many building codes still limit the unit shearing stress to 10,000 pounds per square inch; however, recent practice in building design tends toward the use of 12,000 pounds per square inch.

The safe shears and minimum spans of the tables are calculated for the greatest safe uniformly distributed loads, and are based upon the buckling strength of the webs as given by the above formula, but in no case exceeding a maximum unit shear of 12,000 pounds per square inch.

The uniformly distributed load on a beam must not exceed twice its shearing or buckling resistance.

For loads which produce a shear exceeding the safe crippling resistance, web stiffeners should be provided at points of support and of concentrated loading, and at suitable intervals dependent upon the above.

In general, the crippling resistance of the beam webs for longer lengths, such as floor beams, etc., in buildings, will be found ample for all ordinary cases of loading; but for shorter lengths and heavy loads, the crippling or buckling capacity of the webs should be examined and the design made accordingly, as explained above.

MAXIMUM SAFE SHEAR FOR

BETHLEHEM GIRDER BEAMS,

BASED UPON THE BUCKLING STRENGTH OF THE WEBS.

ALSO THE CORRESPONDING MINIMUM SPANS FOR GREATEST SAFE UNIFORMLY DISTRIBUTED LOADS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	Minimum Span, Feet.
G30	30⅛	200.0	217,400	16.8
	30	190.0	198,400	17.4
	29⅞	181.0	184,200	17.8
G28	28⅛	175.0	185,300	16.1
	28	165.0	167,700	16.8
G26	26⅛	160.0	168,200	15.2
	26	151.0	151,700	15.9
	25⅞	144.0	143,200	16.0
G24a	24⅛	149.0	155,500	14.2
	24	141.0	140,200	14.9
	23⅞	133.0	128,700	15.3
G24	24⅛	129.0	129,100	14.8
	24	121.0	114,100	15.7
	23⅞	114.0	102,900	16.3
G20a	20⅛	149.0	155,400	11.9
	20	142.0	145,400	12.1
	19⅞	135.0	135,500	12.3
G20	20⅛	120.0	123,500	12.1
	20	113.0	113,700	12.3
	19⅞	107.0	106,900	12.3
G18	18⅛	100.0	97,100	11.8
	18	93.0	85,500	12.4
	17⅞	87.5	79,500	12.4
G15b	15⅛	147.0	150,600	8.8
	15	141.0	144,000	8.8
	14⅞	135.0	137,500	8.7
G15a	15⅛	111.0	115,800	9.0
	15	105.0	106,100	9.2
	14⅞	99.0	98,600	9.3
G15	15⅛	80.5	78,400	9.8
	15	74.0	68,700	10.3
	14⅞	69.0	63,700	10.2
G12a	12⅛	76.5	73,900	7.9
	12	70.5	66,000	8.2
	11⅞	66.0	61,900	8.0
G12	12⅛	61.0	55,300	8.6
	12	55.5	49,300	8.8
	$11\frac{29}{32}$	51.5	45,300	8.8
G10	10⅛	50.0	41,500	7.9
	10	44.5	35,000	8.4
	$9\frac{29}{32}$	41.5	33,200	8.2
G9	9⅛	43.5	37,200	6.9
	9	38.5	31,300	7.3
	$8\frac{15}{16}$	36.0	28,400	7.5
G8	8⅛	37.0	31,700	6.1
	8	33.0	27,700	6.2
	$7\frac{15}{16}$	31.0	26,300	6.1

MAXIMUM SAFE SHEAR FOR

BETHLEHEM I BEAMS,

BASED UPON THE BUCKLING STRENGTH OF THE WEBS.

ALSO THE CORRESPONDING MINIMUM SPANS FOR GREATEST SAFE UNIFORMLY DISTRIBUTED LOADS.

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	Minimum Span, Feet.
B30	30⅛	129.0	134,000	16.5
	30	121.0	120,700	17.3
	29⅞	115.0	111,900	17.5
B28	28⅛	113.0	116,200	15.7
	28	106.0	103,800	16.5
	27⅞	100.0	95,700	16.7
B26	26⅛	98.0	99,600	14.8
	26	91.0	88,100	15.5
	25⅞	85.5	80,600	15.8
B24b	24 3/32	104.5	117,300	12.6
	24	99.5	107,900	13.0
	23 29/32	95.5	100,500	13.3
B24a	24	84.5	84,200	14.1
B24	24 3/32	79.5	73,900	15.1
	24	73.5	62,200	16.8
B22	22⅛	71.5	70,300	13.2
	22 1/16	68.5	65,500	13.5
	22	65.5	59,200	14.3
B20a	20 3/32	78.0	82,200	11.4
	20	73.0	72,900	12.1
B20	20⅛	64.5	63,700	12.0
	20 1/16	62.0	60,700	12.1
	20	59.5	56,200	12.5

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Maximum Safe Shear, Pounds.	Minimum Span, Feet.
B18a	18⅛	74.0	74,300	11.0
	18	69.0	68,400	11.1
	17⅞	64.5	62,600	11.2
B18	18⅛	54.5	54,300	10.8
	18 1/16	52.0	50,200	11.2
	18	49.0	43,700	12.1
B15b	15	71.5	87,500	7.2
B15a	15⅛	59.5	71,300	7.4
	15	54.5	61,600	7.9
	14⅞	50.5	55,400	8.1
B15	15 3/32	42.5	41,700	9.3
	15 1/32	40.0	37,100	9.9
	15	38.5	33,800	10.5
B12a	12	36.5	36,100	7.5
B12	12 1/16	31.0	28,600	8.1
	12	28.5	24,900	8.7
B10	10 3/32	26.0	26,900	6.0
	10	23.5	23,600	6.2
B9	9 1/16	22.0	24,100	5.1
	9	20.5	22,600	5.0
B8	8 1/16	19.0	23,800	3.9
	8	17.5	21,200	4.0

EXPLANATION OF TABLES OF
SAFE LOADS FOR BETHLEHEM COLUMNS.

Safe loads, computed by the formula stated below, are given in the tables on pages 110 to 119 for all the sizes of Bethlehem H Columns and Supplementary Sections, and on pages 102 to 109 for Bethlehem Girder Beams and Bethlehem I Beams Used as Columns. Tables for 14-inch H Columns Reinforced with Cover Plates are given on pages 120 and 121, and for Special Compound Columns on pages 122 and 123.

The superiority of steel columns, as compared with columns of other material, is so well understood and recognized as to need little comment. Previous to the introduction of Bethlehem rolled steel columns of integral section, riveted columns were the only kind of steel columns obtainable. In buildings of anything more than the most moderate height, or where stiffness of the frame and maximum security are essential, steel columns are necessarily employed.

Bethlehem rolled column sections require no riveting of the shafts, and this advantage reduces the cost of these steel columns to such an extent, that they can be used economically for all purposes. These rolled columns provide the desired qualities of safety, reliability, and simplicity at a minimum cost.

For very short lengths, the compressive strength of structural steel of standard quality is the same as its tensile strength. As the length increases, the strength as a column diminishes. A short column has practically a uniform compressive strength for all lengths less than about fifteen times its least diameter; but for greater lengths, the strength decreases, the decrease being a function of the length of the column and the Radius of Gyration of the section in the direction of its least resistance to bending.

Conforming to these conditions, the safe allowable stress, f, in pounds per square inch, for columns of structural steel used in building construction, is given by the following formula:—

$$f = \frac{18,000}{1 + \frac{l^2}{18,000r^2}}$$

with a maximum of 15,000 pounds per square inch, which corresponds to a value of $\frac{l}{r} = 60$.

In this formula,

l = Unsupported length of column, in inches, and
r = Corresponding least Radius of Gyration, in inches.

Columns proportioned in accordance with this formula have the same relative degree of safety as beams and girders designed for a maximum fiber stress of 18,000 pounds per square inch in bending, thus securing a structure symmetrically proportioned in all its parts.

The unsupported length of a column or main compression member should not exceed 120 times its least Radius of Gyration, and this limit is indicated in the tables by full lines for the least Radius of Gyration of the section. Safe loads to the right and below this line are given for ratios of $\frac{l}{r}$ up to about 150 and may be used for bracing and other secondary members.

An example is given on page 101, showing the method of selecting rolled H column sections for buildings. Wherever possible, it is desirable to provide for the given range of loads by selecting the different weights of column sections required from the various sizes listed under the same section number. Columns thus selected will better fit together when superimposed and can be obtained from the same rolling, thereby avoiding delay in delivery.

Abutting sections of columns, in addition to having machine squared ends, should be connected by splices of sufficient size to maintain the continuity of section required and preserve the rigidity of the steel frame work of the building or structure. The method of splicing column sections and the manner of connecting beams and girders are shown by the illustrations on pages 142 to 149. The weights, in pounds per foot, given in the tables for the various column sections, are for the column shafts only and do not include splices or connections of any kind.

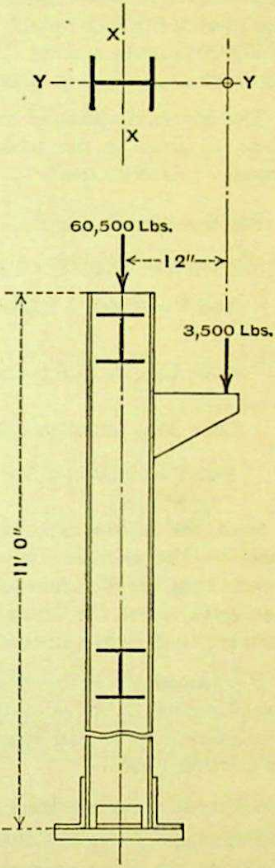
Bending Factors. The safe loads given in the tables are for concentric or symmetrical loading. When the loads are not centrally or symmetrically applied, bending is produced in the column, the effect of which must be considered. To aid in the selection of columns subjected to direct loads, and also to bending produced by eccentric loads or by other means, Bending Factors are given which furnish a convenient and practical method of converting the Bending Moment into an equivalent direct central load. The derivation of the Bending Factors, the use of which is illustrated below, is given on page 39.

If the Bending Moment, in inch pounds, is multiplied by the Bending Factor, k, the product is an equivalent central load on the column, producing the same compressive stress as the Bending Moment.

The effect of eccentric loading is easily calculated by the use of the Bending Factors, and the proper section may then be selected to meet the conditions. The Bending Factors about both principal axes for all Bethlehem sections are given in the Tables of Safe Loads for Columns.

Example: A column with an unsupported length of 11 feet carries a centrally applied load of 60,500 pounds and an eccentric load of 3,500 pounds applied at a distance of 12 inches from the center line. What is the size of column required?

Using the notation and procedure in the selection of columns subjected to direct loads and bending given on page 39, the calculation is as follows:—



The Bending Moment, $M = 3{,}500 \times 12 = 42{,}000$ inch pounds. Assume the Bending Factor $k = \frac{1}{3}$; then $Mk = 42{,}000 \times \frac{1}{3} = 14{,}000$ pounds.

The total equivalent central load, $P = 60{,}500 + 3{,}500 + 14{,}000 = 78{,}000$ pounds.

Selecting a proper and economical column from the safe load tables, two sections are found capable of carrying a load of approximately 78,000 pounds on an 11 foot length; namely:—the 10-inch B x 23.5 pound beam, page 109, carrying a safe load of 77,000 pounds, and the H 8/6.5 x 23.5 pound column, page 119, carrying a safe load of about 87,000 pounds.

The accurate values of the Bending Factors, k, for these sections, as given in the tables, are used below in obtaining the actual equivalent loads.

For the 10-inch B x 23.5 pound beam, $k = 0.283$

Then $Mk = 42{,}000 \times 0.283 = 11{,}900$ pounds.

And $P = 60{,}500 + 3{,}500 + 11{,}900 = 75{,}900$ pounds.

For the $H\frac{8}{6.5}$ x 23.5 pound column, $k = 0.349$.

Then $Mk = 42{,}000 \times 0.349 = 14{,}700$ pounds.

And $P = 60{,}500 + 3{,}500 + 14{,}700 = 78{,}700$ pounds.

Both the above calculated loads are within the allowable limits for the sections selected, and both sections have the same weight, but the 8-inch column has the advantage of occupying less space than the 10-inch I beam column, and is slightly stronger under the imposed conditions.

If columns are to be designed for any other stress than the base stress of 18,000 pounds per square inch of the formula, the new loads may be had approximately from the tables by direct proportion thus:—

Approximate new load : tabular load : : new stress : 18,000.

Drawings of typical details and arrangement of Bethlehem Columns are given on pages 142 and 143.

EXAMPLE

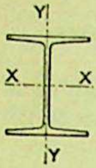
SHOWING THE METHOD OF SELECTING BETHLEHEM ROLLED H COLUMNS FOR BUILDINGS.

The interior columns of a 16-story building are taken as an example. The actual story heights and the actual loads on the columns are given in the following table:

Story.	Height of Story, Feet.	Load on Column, Pounds.	H COLUMN SECTION REQUIRED.					
			Safe Load, Pounds.	DIMENSIONS, IN INCHES.			Weight per Foot, Pounds.	Section Number.
				D	T	B		
16th	12	54,000	128,000	7⅞	7/16	8.00	32.0	H8
15th	13	106,000	168,000	8¼	⅝	8.08	44.0	H8
14th	14	158,000						
13th	13	208,000	261,000	10⅛	11/16	10.04	60.5	H10
12th	13	256,000						
11th	13	302,000	363,000	10⅝	15/16	10.20	83.5	H10
10th	13	348,000						
9th	13	392,000	440,000	11	1⅛	10.31	100.5	H10
8th	13	436,000						
7th	13	480,000	523,000	12¾	1⅛	12.23	119.5	H12
6th	13	520,000						
5th	13	560,000	609,000	14⅝	1⅛	14.19	139.0	H14
4th	13	600,000						
3rd	13	640,000	680,000	14⅞	1¼	14.27	155.0	H14
2nd	15	680,000						
1st	17	724,000	788,000	15¼	1 7/16	14.39	179.5	H14
Basement.	12	788,000						

Columns for buildings are usually selected in lengths of two stories. By inspection of the Tables of Safe Loads for H columns, it is found that no columns smaller than 14-inch H sections have sufficient capacity for the lower stories. From the table on page 110 the 14-inch H columns required are then selected for the lower stories; and from the tables on pages 112, 114 and 116 the 12-inch, 10-inch, and 8-inch columns are selected for the upper stories.

Where there is no limitation as to the size of the column, the largest dimension column having the required capacity will be the most economical.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM GIRDER BEAMS USED AS COLUMNS.

Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

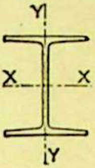
$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.						
					12	13	14	15	16	17	18
	30⅛	200.0	58.52	3.28	878	878	878	878	878	867	849
G30	30	190.0	55.52	3.26	833	833	833	833	833	821	803
	29⅞	181.0	52.82	3.23	792	792	792	792	792	778	762
G28	28⅛	175.0	51.02	3.12	765	765	765	765	759	742	725
	28	165.0	48.19	3.10	723	723	723	723	715	699	683
	26⅛	160.0	46.85	3.04	703	703	703	703	690	675	659
G26	26	151.0	44.16	3.02	662	662	662	662	649	634	619
	25⅞	144.0	41.99	2.99	630	630	630	629	615	601	586
	24⅛	149.0	43.57	2.97	654	654	654	651	636	621	603
G24a	24	141.0	41.02	2.95	615	615	615	612	598	583	569
	23⅞	133.0	38.71	2.92	581	581	581	575	562	548	534
	24⅛	129.0	37.74	2.72	566	566	561	546	532	518	503
G24	24	121.0	35.30	2.70	530	530	523	510	496	482	469
	23⅞	114.0	33.12	2.67	497	497	489	476	463	450	437
	20⅛	149.0	43.44	2.97	652	652	652	649	635	620	604
G20a	20	142.0	41.31	2.96	620	620	620	617	603	588	574
	19⅞	135.0	39.18	2.94	588	588	588	584	570	556	543
	20⅛	120.0	34.95	2.73	524	524	520	507	493	480	467
G20	20	113.0	32.90	2.71	494	494	488	476	463	450	438
	19⅞	107.0	31.06	2.68	466	466	459	447	435	423	411
	18⅛	100.0	29.25	2.63	439	439	429	418	406	395	383
G18	18	93.0	27.14	2.61	407	407	397	386	376	365	354
	17⅞	87.5	25.40	2.58	381	380	370	360	350	339	329

Beams not secured against yielding sideways and free to fail in the direction of the least Radius of Gyration. For detail dimensions see pages 124 and 126.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM GIRDER BEAMS USED AS COLUMNS.

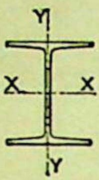


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.										BENDING FACTORS.		Section Number.
20	22	24	26	28	30	32	34	36	38	AXIS X-X. k	AXIS Y-Y. k′	
812	775	737	701	665	631	598	566	536	508	.096	.700	G30
768	733	697	662	628	596	564	534	506	479	.096	.706	
728	693	659	626	594	563	533	504	477	451	.096	.716	
691	657	623	590	559	528	499	471	445	420	.103	.735	G28
651	618	586	555	525	496	468	442	417	394	.103	.742	
626	594	563	532	502	474	447	422	397	375	.110	.746	G26
588	558	528	499	471	444	419	395	372	......	.110	.754	
557	527	499	471	444	419	394	372	350	......	.110	.769	
575	545	515	486	458	432	407	383	361	......	.118	.755	G24a
540	511	483	455	429	404	380	358	337	......	.118	.763	
507	479	452	426	401	378	355	334	314	......	.118	.774	
474	446	419	392	368	344	322	302	......	......	.118	.834	G24
442	415	389	365	342	320	299	......	......	......	.118	.842	
411	386	362	339	317	297	277	......	......	......	.118	.855	
574	543	514	485	457	431	405	382	359	......	.141	.722	G20a
545	516	487	460	433	408	384	362	341	......	.141	.730	
515	487	460	434	409	385	362	341	321	......	.141	.738	
440	414	389	365	342	320	300	281	......	......	.140	.808	G20
412	388	364	341	319	299	280	......	......	......	.141	.820	
387	363	341	319	298	279	261	......	......	......	.141	.837	
360	338	316	295	276	258	241	......	......	......	.154	.833	G18
332	311	291	272	254	238	222	......	......	......	.153	.843	
309	289	270	252	235	220	205	......	......	......	.154	.863	

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM GIRDER BEAMS USED AS COLUMNS.

Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

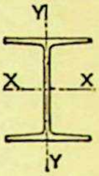
$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.						
					8	9	10	11	12	13	14
G15b	15⅛	147.0	42.73	2.85	641	641	641	641	641	641	641
	15	141.0	40.86	2.83	613	613	613	613	613	613	613
	14⅞	135.0	39.01	2.82	585	585	585	585	585	585	585
G15a	15⅛	111.0	32.40	2.67	486	486	486	486	486	486	478
	15	105.0	30.45	2.65	457	457	457	457	457	457	448
	14⅞	99.0	28.65	2.63	430	430	430	430	430	430	420
G15	15⅛	80.5	23.44	2.47	352	352	352	352	352	345	336
	15	74.0	21.55	2.45	323	323	323	323	323	317	308
	14⅞	69.0	19.96	2.41	299	299	299	299	299	291	283
G12a	12⅛	76.5	22.29	2.43	334	334	334	334	334	326	317
	12	70.5	20.57	2.41	309	309	309	309	309	300	292
	11⅞	66.0	19.11	2.38	287	287	287	287	286	278	269
G12	12⅛	61.0	17.77	2.32	267	267	267	267	263	256	248
	12	55.5	16.21	2.29	243	243	243	243	239	232	225
	11 29/32	51.5	15.07	2.26	226	226	226	226	221	214	208
G10	10⅛	50.0	14.51	2.14	218	218	218	216	209	202	195
	10	44.5	13.03	2.11	195	195	195	193	186	180	173
	9 29/32	41.5	12.12	2.08	182	182	182	178	172	166	160
G9	9⅛	43.5	12.62	2.02	189	189	189	184	177	171	164
	9	38.5	11.23	1.99	168	168	168	162	157	151	145
	8 15/16	36.0	10.55	1.97	158	158	157	152	146	141	135
G8	8⅛	37.0	10.77	1.90	162	162	159	153	147	141	135
	8	33.0	9.57	1.86	144	144	140	135	129	124	119
	7 15/16	31.0	9.01	1.84	135	135	131	126	121	116	111

Beams not secured against yielding sideways and free to fail in the direction of the least Radius of Gyration. For detail dimensions see page 128.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM GIRDER BEAMS USED AS COLUMNS.

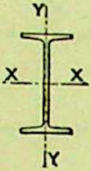


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\dfrac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.										BENDING FACTORS.		Section Number.
16	18	20	22	24	26	28	30	32	34	AXIS X-X. k	AXIS Y-Y. k′	
614	583	552	521	491	462	434	408	383	360	.194	.725	G15b
586	556	526	496	467	439	412	387	364	341	.194	.731	
558	530	501	472	445	418	393	369	346	325	.195	.738	
453	428	403	378	354	332	310	290	271	......	.188	.791	G15a
424	400	377	353	331	310	290	271	253	......	.187	.799	
398	375	353	331	310	289	270	253	236	......	.188	.810	
316	296	277	258	240	224	208	194	......	......	.183	.884	G15
289	271	253	236	219	204	190	176	......	......	.183	.898	
266	248	232	216	200	186	173	160	......	......	.184	.925	
298	279	260	242	225	209	195	181	......	......	.229	.868	G12a
274	256	239	222	206	192	178	165	......	......	.229	.881	
253	236	220	204	190	176	163	......	......	......	.231	.903	
232	216	201	186	172	160	148	......	......	......	.224	.930	G12
210	195	181	168	155	144	133	......	......	......	.225	.954	
194	180	167	154	143	132	122	......	......	......	.226	.978	
180	167	154	142	130	120	......	......	......	......	.267	.987	G10
161	148	136	125	115	106	......	......	......	......	.266	1.007	
148	136	125	115	106	97	......	......	......	......	.268	1.036	
151	139	127	117	107	......	......	......	......	......	.297	1.051	G9
133	122	112	102	93	......	......	......	......	......	.297	1.076	
124	114	104	95	87	......	......	......	......	......	.297	1.091	
124	113	103	94	......	......	......	......	......	......	.334	1.116	G8
108	98	89	81	......	......	......	......	......	......	.335	1.154	
101	92	83	76	......	......	......	......	......	......	.337	1.181	

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM I BEAMS USED AS COLUMNS.

Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

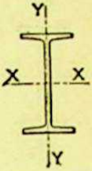
$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET. 7	8	9	10	11	12	13
B30	30⅛	129.0	37.52	2.18	563	563	563	563	561	544	526
	30	121.0	35.36	2.16	530	530	530	530	527	510	493
	29⅞	115.0	33.50	2.13	503	503	503	503	497	481	465
B28	28⅛	113.0	32.98	2.08	495	495	495	495	485	469	452
	28	106.0	30.93	2.06	464	464	464	464	453	438	422
	27⅞	100.0	29.18	2.03	438	438	438	438	425	410	395
B26	26⅛	98.0	28.47	1.97	427	427	427	425	410	395	380
	26	91.0	26.55	1.95	398	398	398	395	381	367	353
	25⅞	85.5	24.89	1.92	373	373	373	368	355	341	328
B24b	24 3/32	104.5	30.63	2.08	459	459	459	459	451	435	420
	24	99.5	29.15	2.07	437	437	437	437	428	414	399
	23 29/32	95.5	27.79	2.05	417	417	417	417	407	393	378
B24a	24	84.5	24.75	1.97	371	371	371	369	357	344	330
B24	24 3/32	79.5	23.17	1.87	348	348	348	339	327	314	301
	24	73.5	21.52	1.86	323	323	323	315	303	291	279
B22	22⅛	71.5	20.88	1.78	313	313	312	300	288	276	263
	22 1/16	68.5	20.04	1.76	301	301	298	287	275	263	251
	22	65.5	19.08	1.76	286	286	284	273	262	250	239
B20a	20 3/32	78.0	22.77	1.93	342	342	342	337	325	313	301
	20	73.0	21.37	1.92	321	321	321	316	305	293	281
B20	20⅛	64.5	18.79	1.70	282	282	276	265	253	242	230
	20 1/16	62.0	18.11	1.69	272	272	266	255	243	232	221
	20	59.5	17.33	1.68	260	260	254	243	232	222	211

Beams not secured against yielding sideways and free to fail in the direction of the least Radius of Gyration. For detail dimensions see pages 130 and 132.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM I BEAMS USED AS COLUMNS.

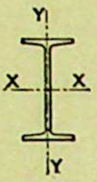


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.										BENDING FACTORS.		Section Number.
14	15	16	17	18	19	20	22	24	26	AXIS X-X. k	AXIS Y-Y. k'	
508	490	472	454	437	420	404	372	343	316	.102	1.113	B30
476	459	442	426	409	393	378	348	320	295	.102	1.130	
448	432	415	399	384	368	354	325	299	275	.102	1.157	
436	419	403	387	371	356	341	313	287	264	.108	1.162	B28
407	391	376	360	346	331	317	291	267	......	.108	1.181	
380	366	351	336	322	309	296	271	248	......	.109	1.212	
365	350	335	321	307	294	281	257	234	......	.116	1.227	B26
338	324	311	297	284	272	260	237	216	......	.116	1.250	
314	301	288	275	263	251	240	219	199	......	.118	1.287	
405	389	374	359	345	331	317	291	267	245	.124	1.127	B24b
384	369	355	341	327	313	300	276	253	......	.124	1.138	
364	350	336	323	309	296	284	260	239	......	.125	1.155	
317	304	292	279	267	255	244	223	204	......	.125	1.227	B24a
288	275	263	251	240	228	218	198	......	......	.124	1.289	B24
267	255	243	232	221	211	201	183	......	......	.124	1.296	
251	240	228	217	207	197	187	169	......	......	.135	1.354	B22
239	228	217	207	196	187	177	160	......	......	.136	1.369	
228	217	207	197	187	178	169	153	......	......	.135	1.380	
288	276	264	253	242	231	220	201	183	......	.146	1.198	B20a
270	258	247	236	226	216	206	188	171	......	.146	1.208	
219	208	198	188	178	169	161	......	......	......	.147	1.389	B20
210	200	190	180	171	162	154	......	......	......	.148	1.409	
201	190	181	171	163	154	146	......	......	......	.148	1.425	

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM I BEAMS USED AS COLUMNS.

Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

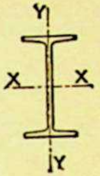
$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

Section Number.	Nominal Depth of Beam, Inches.	Weight per Foot, Pounds.	Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.						
					4	5	6	7	8	9	10
B18a	18⅛	74.0	21.61	1.96	324	324	324	324	324	324	322
	18	69.0	20.20	1.93	303	303	303	303	303	303	299
	17⅞	64.5	18.79	1.91	282	282	282	282	282	282	277
B18	18⅛	54.5	15.95	1.60	239	239	239	239	239	229	219
	18 1/16	52.0	15.22	1.59	228	228	228	228	228	218	208
	18	49.0	14.32	1.59	215	215	215	215	214	205	196
B15b	15	71.5	20.79	1.71	312	312	312	312	312	306	294
B15a	15⅛	59.5	17.32	1.57	260	260	260	260	258	247	235
	15	54.5	15.87	1.56	238	238	238	238	236	226	215
	14⅞	50.5	14.66	1.54	220	220	220	220	217	207	197
B15	15 3/32	42.5	12.39	1.47	186	186	186	186	180	172	163
	15 1/32	40.0	11.68	1.47	175	175	175	175	170	162	153
	15	38.5	11.26	1.46	169	169	169	169	163	155	147
B12a	12	36.5	10.60	1.44	159	159	159	159	153	145	138
B12	12 1/16	31.0	9.02	1.38	135	135	135	135	128	121	114
	12	28.5	8.40	1.38	126	126	126	125	119	113	106
B10	10 3/32	26.0	7.61	1.28	114	114	114	111	104	98	92
	10	23.5	6.89	1.26	103	103	103	99	94	88	82
B9	9 1/16	22.0	6.45	1.21	97	97	97	92	86	80	75
	9	20.5	6.02	1.19	90	90	90	85	80	74	69
B8	8 1/16	19.0	5.62	1.13	84	84	83	77	72	67	62
	8	17.5	5.14	1.11	77	77	75	70	65	61	56

Beams not secured against yielding sideways and free to fail in the direction of the least Radius of Gyration. For detail dimensions see pages 132 and 134.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM I BEAMS USED AS COLUMNS.



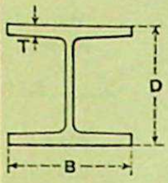
Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.										BENDING FACTORS.		Section Number.
11	12	13	14	15	16	17	18	20	22	AXIS X-X. k	AXIS Y-Y. k′	
311	299	288	276	265	254	243	232	212	194	.158	1.143	B18a
289	278	267	256	245	235	224	214	196	178	.159	1.169	
267	257	247	237	226	217	207	198	180	164	.160	1.199	
208	198	188	178	169	160	151	143	128	......	.163	1.464	B18
198	188	178	169	160	151	143	135	......	......	.163	1.482	
186	177	168	159	151	142	135	127	......	......	.162	1.486	
281	268	256	244	232	220	209	198	179	......	.198	1.281	B15b
224	212	201	191	180	170	161	152	......	......	.196	1.425	B15a
204	194	184	174	164	155	146	138	......	......	.195	1.441	
187	178	168	159	150	142	134	126	......	......	.196	1.472	
154	145	137	129	122	115	108	101	......	......	.192	1.564	B15
145	137	129	122	115	108	102	96	......	......	.192	1.576	
139	132	124	117	110	103	97	91	......	......	.191	1.574	
130	123	115	109	102	96	90	85	......	......	.236	1.540	B12a
108	101	95	89	83	78	73	......	......	......	.234	1.635	B12
100	94	88	83	78	73	68	......	......	......	.234	1.652	
86	80	75	70	65	61	......	......	......	......	.281	1.757	B10
77	72	67	62	58	......	......	......	......	......	.283	1.812	
70	65	60	56	52	......	......	......	......	......	.314	1.885	B9
64	60	55	51	......	......	......	......	......	......	.317	1.941	
58	53	49	45	......	......	......	......	......	......	.360	2.055	B8
52	48	44	......	......	......	......	......	......	......	.361	2.112	

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 14″ H COLUMNS.

Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

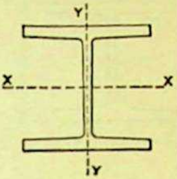
Section Number.	Weight per Foot, Pounds.	DIMENSIONS, INCHES.			Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.				
		D	T	B			16	17	18	19	20
H14	84.0	13¾	11/16	13.92	24.46	3.47	367	367	362	355	348
	92.0	13⅞	¾	13.96	26.76	3.49	401	401	397	389	381
	100.0	14	13/16	14.00	29.06	3.50	436	436	432	423	415
	107.5	14⅛	⅞	14.04	31.38	3.52	471	471	467	458	449
	115.5	14¼	15/16	14.08	33.70	3.54	506	506	503	493	483
	123.5	14⅜	1	14.12	36.04	3.55	541	541	538	528	517
	131.5	14½	1 1/16	14.16	38.38	3.57	576	576	574	563	552
	139.0	14⅝	1⅛	14.19	40.59	3.58	609	609	608	596	585
	147.0	14¾	1 3/16	14.23	42.95	3.60	644	644	644	632	620
	155.0	14⅞	1¼	14.27	45.33	3.61	680	680	680	668	655
	163.0	15	1 5/16	14.31	47.71	3.62	716	716	716	704	690
	171.5	15⅛	1⅜	14.35	50.11	3.64	752	752	752	741	727
	179.5	15¼	1 7/16	14.39	52.51	3.65	788	788	788	777	762
	187.5	15⅜	1½	14.43	54.92	3.66	824	824	824	813	798
	196.0	15½	1 9/16	14.47	57.35	3.68	860	860	860	851	835
	204.5	15⅝	1⅝	14.51	59.78	3.69	897	897	897	888	871
	212.0	15¾	1 11/16	14.54	62.07	3.70	931	931	931	923	906
	220.5	15⅞	1¾	14.58	64.52	3.71	968	968	968	960	942
	228.5	16	1 13/16	14.62	66.98	3.72	1005	1005	1005	997	979
	237.0	16⅛	1⅞	14.66	69.45	3.74	1042	1042	1042	1036	1017
	245.5	16¼	1 15/16	14.70	71.94	3.75	1079	1079	1079	1074	1055
	254.0	16⅜	2	14.74	74.43	3.76	1116	1116	1116	1112	1093
	262.5	16½	2 1/16	14.78	76.93	3.77	1154	1154	1154	1151	1130
	271.0	16⅝	2⅛	14.82	79.44	3.79	1192	1192	1192	1191	1169
	279.5	16¾	2 3/16	14.86	81.97	3.80	1230	1230	1230	1230	1208
	288.5	16⅞	2¼	14.90	84.50	3.81	1268	1268	1268	1268	1246

For detail dimensions see page 56.

For 14″ Columns of lighter weight see pages 118 and 119.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 14″ H COLUMNS.

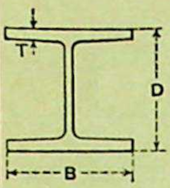


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.									BENDING FACTORS.		Weight per Foot, Pounds.
22	24	26	28	30	32	35	40	45	AXIS X-X. k	AXIS Y-Y. k′	
333	318	304	289	276	262	243	213	....	.190	.578	84.0
365	349	334	318	303	288	267	235	....	.190	.574	92.0
397	380	363	346	329	313	291	256	....	.190	.570	100.0
430	412	393	375	357	340	315	278	....	.190	.566	107.5
463	444	424	404	385	367	340	300	....	.190	.563	115.5
496	475	454	433	413	393	365	322	....	.190	.560	123.5
530	507	485	463	441	421	391	345	....	.190	.557	131.5
561	537	514	491	468	446	414	366	....	.189	.553	139.0
595	570	545	521	497	474	440	389	344	.189	.550	147.0
629	603	577	551	526	501	466	412	364	.189	.548	155.0
663	635	608	581	554	528	491	434	384	.189	.545	163.0
698	669	641	612	584	557	518	459	406	.189	.543	171.5
732	702	672	643	614	585	545	482	427	.189	.541	179.5
767	736	704	673	643	613	571	506	447	.189	.538	187.5
803	770	738	706	674	643	599	531	470	.188	.536	196.0
838	804	770	737	704	672	626	555	491	.188	.534	204.5
871	836	801	766	732	699	651	577	512	.188	.531	212.0
906	870	834	798	762	728	678	602	533	.188	.529	220.5
942	904	867	830	793	757	706	626	555	.187	.527	228.5
979	940	902	863	825	788	735	653	579	.187	.525	237.0
1015	975	935	896	856	818	763	678	602	.187	.523	245.5
1052	1010	969	928	888	848	791	703	624	.187	.521	254.0
1088	1046	1003	961	919	878	820	729	647	.187	.519	262.5
1126	1083	1039	995	953	911	850	756	672	.186	.517	271.0
1164	1119	1073	1029	985	941	879	782	695	.186	.515	279.5
1201	1155	1108	1062	1017	972	908	808	719	.186	.513	288.5

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 12″ H COLUMNS.

Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

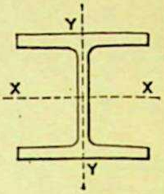
Section Number.	Weight per Foot, Pounds.	DIMENSIONS, INCHES.			Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.					
		D	T	B			13	14	15	16	17	18
H12	65.5	11¾	⅝	11.92	19.00	2.98	285	285	284	278	271	265
	72.5	11⅞	¹¹⁄₁₆	11.96	20.96	3.00	314	314	314	307	300	293
	79.0	12	¾	12.00	22.94	3.01	344	344	344	337	329	321
	85.5	12⅛	¹³⁄₁₆	12.04	24.92	3.03	374	374	374	367	358	350
	92.5	12¼	⅞	12.08	26.92	3.04	404	404	404	397	388	378
	99.5	12⅜	¹⁵⁄₁₆	12.12	28.92	3.06	434	434	434	427	417	408
	106.0	12½	1	12.16	30.94	3.07	464	464	464	458	447	437
	113.0	12⅝	1¹⁄₁₆	12.20	32.96	3.08	494	494	494	488	477	466
	119.5	12¾	1⅛	12.23	34.87	3.10	523	523	523	517	506	494
	126.5	12⅞	1³⁄₁₆	12.27	36.91	3.11	554	554	554	548	536	524
	133.5	13	1¼	12.31	38.97	3.13	585	585	585	580	568	555
	140.5	13⅛	1⁵⁄₁₆	12.35	41.03	3.14	615	615	615	612	598	585
	147.5	13¼	1⅜	12.39	43.10	3.15	647	647	647	643	629	615
	154.5	13⅜	1⁷⁄₁₆	12.43	45.19	3.16	678	678	678	675	661	646
	162.0	13½	1½	12.47	47.28	3.18	709	709	709	708	693	677
	169.0	13⅝	1⁹⁄₁₆	12.51	49.38	3.19	741	741	741	740	724	708
	176.0	13¾	1⅝	12.55	51.50	3.20	773	773	773	773	756	740
	183.0	13⅞	1¹¹⁄₁₆	12.58	53.48	3.21	802	802	802	802	786	769
	190.0	14	1¾	12.62	55.62	3.23	834	834	834	834	820	802

For detail dimensions see page 58.

For 12″ Columns of lighter weight see pages 118 and 119.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 12″ H COLUMNS.

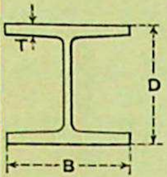


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.										BENDING FACTORS.		Weight per Foot, Pounds.
20	22	24	26	28	30	32	34	36	38	AXIS X-X. k	AXIS Y-Y. k′	
251	238	225	213	200	189	178	168	158	......	.224	.672	65.5
278	264	250	236	222	210	198	186	175	......	.224	.666	72.5
305	289	274	259	244	230	217	204	193	......	.224	.661	79.0
333	316	299	282	266	251	237	223	211	......	.224	.657	85.5
360	341	323	306	289	272	257	242	228	215	.223	.652	92.5
388	368	349	330	312	294	278	262	247	233	.223	.649	99.5
416	395	374	354	334	316	298	281	265	250	.223	.645	106.0
444	421	399	378	357	337	318	300	283	268	.223	.641	113.0
471	447	424	402	380	359	339	320	302	285	.222	.637	119.5
499	474	450	426	403	381	360	340	321	303	.222	.633	126.5
529	503	477	452	428	404	382	361	341	322	.222	.630	133.5
558	530	503	477	451	427	403	381	360	340	.222	.627	140.5
587	558	530	502	475	450	425	402	379	358	.221	.624	147.5
616	586	557	528	500	473	447	422	399	377	.221	.621	154.5
646	615	585	554	525	497	470	445	420	397	.221	.618	162.0
676	644	612	580	550	521	492	466	440	416	.221	.615	169.0
706	673	639	607	575	544	515	487	461	436	.220	.612	176.0
735	700	665	631	598	567	536	507	480	454	.220	.609	183.0
766	730	694	659	625	592	561	531	502	475	.220	.607	190.0

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 10″ H COLUMNS.

Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

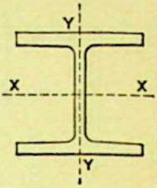
Section Number.	Weight per Foot, Pounds.	DIMENSIONS, INCHES.			Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.				
		D	T	B			11	12	13	14	15
H10	49.5	9⅞	9/16	9.97	14.37	2.49	216	216	212	206	200
	55.0	10	⅝	10.00	15.91	2.51	239	239	236	229	223
	60.5	10⅛	11/16	10.04	17.57	2.53	264	264	261	254	247
	66.0	10¼	¾	10.08	19.23	2.54	288	288	286	278	271
	72.0	10⅜	13/16	10.12	20.91	2.56	314	314	312	304	295
	77.5	10½	⅞	10.16	22.59	2.57	339	339	338	329	320
	83.5	10⅝	15/16	10.20	24.29	2.58	364	364	363	354	344
	89.0	10¾	1	10.24	25.99	2.60	390	390	390	380	369
	95.0	10⅞	1 1/16	10.28	27.71	2.61	416	416	416	405	395
	100.5	11	1⅛	10.31	29.32	2.62	440	440	440	430	418
	106.5	11⅛	1 3/16	10.35	31.06	2.64	466	466	466	456	444
	112.0	11¼	1¼	10.39	32.80	2.65	492	492	492	483	470
	118.0	11⅜	1 5/16	10.43	34.55	2.66	518	518	518	509	496
	124.0	11½	1⅜	10.47	36.32	2.67	545	545	545	536	522
	130.0	11⅝	1 7/16	10.51	38.09	2.68	571	571	571	563	548
	136.5	11¾	1½	10.55	39.88	2.70	598	598	598	591	576

For detail dimensions see page 60.

For 10″ Columns of lighter weight see pages 118 and 119.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 10″ H COLUMNS.



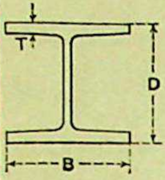
Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.									BENDING FACTORS.		Weight per Foot, Pounds.
16	18	20	22	24	26	28	30	32	AXIS X-X. k	AXIS Y-Y. k′	
194	182	171	159	148	138	129	120	......	.269	.804	49.5
216	203	190	177	165	154	144	134	......	.268	.792	55.0
240	225	211	197	184	171	160	149	......	.268	.786	60.5
263	247	231	216	202	188	176	164	......	.268	.780	66.0
287	270	253	237	221	206	192	179	167	.268	.775	72.0
310	292	274	256	240	224	209	195	182	.267	.770	77.5
334	315	295	276	258	241	225	210	196	.267	.765	83.5
359	338	318	297	278	260	243	227	212	.267	.760	89.0
383	361	339	318	298	278	260	242	226	.267	.755	95.0
406	383	360	337	316	295	276	258	241	.266	.749	100.5
432	408	383	359	337	315	294	275	257	.265	.746	106.5
457	431	406	381	356	334	312	292	273	.265	.741	112.0
482	455	428	402	377	352	330	308	288	.265	.737	118.0
508	479	451	424	397	372	348	325	304	.264	.733	124.0
534	504	474	445	418	391	366	342	320	.264	.729	130.0
560	530	499	469	440	412	386	361	338	.263	.726	136.5

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 8″ H COLUMNS.

Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

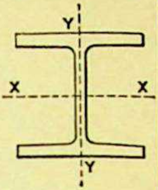
Section Number.	Weight per Foot, Pounds.	DIMENSIONS, INCHES.			Area, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.					
		D	T	B			8	9	10	11	12	13
H8	32.0	7⅞	7/16	8.00	9.17	1.98	138	138	137	132	128	123
	35.0	8	½	8.00	10.17	2.01	153	153	153	148	142	137
	39.5	8⅛	9/16	8.04	11.50	2.03	173	173	173	168	162	156
	44.0	8¼	⅝	8.08	12.83	2.04	192	192	192	187	181	174
	48.5	8⅜	11/16	8.12	14.18	2.05	213	213	213	207	200	193
	53.0	8½	¾	8.16	15.53	2.07	233	233	233	228	220	212
	58.0	8⅝	13/16	8.20	16.90	2.08	254	254	254	249	240	232
	62.5	8¾	⅞	8.24	18.27	2.09	274	274	274	269	260	251
	67.5	8⅞	15/16	8.28	19.66	2.11	295	295	295	291	281	271
	72.0	9	1	8.32	21.05	2.12	316	316	316	312	302	291
	77.0	9⅛	1 1/16	8.36	22.46	2.13	337	337	337	333	322	311
	81.5	9¼	1⅛	8.39	23.78	2.14	357	357	357	353	342	330
	86.0	9⅜	1 3/16	8.43	25.20	2.16	378	378	378	376	364	352
	91.0	9½	1¼	8.47	26.64	2.17	400	400	400	398	385	373

For detail dimensions see page 62.

For 8″ Columns of lighter weight see pages 118 and 119.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM 8″ H COLUMNS.

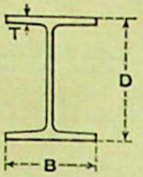


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.										BENDING FACTORS.		Weight per Foot, Pounds.
14	15	16	17	18	19	20	22	24	26	AXIS X-X. k	AXIS Y-Y. k′	
118	113	108	104	99	95	91	83	76	......	.342	1.025	32.0
132	127	121	116	112	107	102	93	86	......	.335	.990	35.0
150	144	138	133	127	122	117	107	98	......	.335	.979	39.5
168	161	155	148	142	136	131	120	110	......	.334	.971	44.0
186	179	172	165	158	151	145	133	122	......	.334	.963	48.5
205	197	189	182	174	167	160	147	135	......	.334	.956	53.0
223	215	206	198	190	182	175	161	147	135	.333	.948	58.0
242	233	224	215	206	198	190	174	160	147	.333	.941	62.5
262	252	242	233	224	215	206	189	174	160	.332	.934	67.5
281	271	260	250	240	231	221	204	187	172	.332	.928	72.0
300	289	279	268	257	247	237	218	201	184	.331	.921	77.0
319	307	296	284	273	263	252	232	213	196	.330	.914	81.5
340	327	315	303	292	280	269	248	228	210	.329	.907	86.0
360	347	334	322	309	297	286	263	242	223	.328	.902	91.0

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM COLUMNS.

SUPPLEMENTARY SECTIONS.

Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

Section Number.	Weight per Foot, Pounds.	Dimensions, Inches. Nominal D	Dimensions, Inches. Nominal T	Dimensions, Inches. B	Area, Square Inches.	Least Radius of Gyration, Inches.	Unsupported Length, in Feet. 6	7	8	9
$H\frac{14}{8}$	43.0	13⅜	½	8.00	12.28	1.88	184	184	184	184
	48.0	13½	9/16	8.04	13.82	1.90	207	207	207	207
	53.5	13⅝	⅝	8.08	15.37	1.91	231	231	231	231
	58.5	13¾	11/16	8.12	16.93	1.92	254	254	254	254
$H\frac{14}{10}$	55.0	13½	9/16	10.00	15.95	2.42	239	239	239	239
	61.5	13⅝	⅝	10.04	17.75	2.43	266	266	266	266
	67.5	13¾	11/16	10.08	19.55	2.44	293	293	293	293
	73.5	13⅞	¾	10.12	21.37	2.46	321	321	321	321
$H\frac{14}{12}$	69.0	13⅝	⅝	12.00	20.04	2.95	301	301	301	301
	76.0	13¾	11/16	12.04	22.09	2.97	331	331	331	331
	83.0	13⅞	¾	12.08	24.15	2.98	362	362	362	362
	90.0	14	13/16	12.12	26.22	3.00	393	393	393	393
$H\frac{12}{8}$	40.5	11½	½	8.00	11.55	1.92	173	173	173	173
	45.5	11⅝	9/16	8.04	13.02	1.94	195	195	195	195
	50.5	11¾	⅝	8.08	14.49	1.95	217	217	217	217
	55.0	11⅞	11/16	8.12	15.98	1.96	240	240	240	240
$H\frac{12}{10}$	52.5	11⅝	9/16	10.00	15.11	2.46	227	227	227	227
	58.0	11¾	⅝	10.04	16.83	2.48	252	252	252	252
	64.0	11⅞	11/16	10.08	18.56	2.49	278	278	278	278
	70.0	12	¾	10.12	20.30	2.50	305	305	305	305
$H\frac{10}{8}$	33.5	9⅝	7/16	8.00	9.60	1.95	144	144	144	144
	38.0	9¾	½	8.03	10.89	1.97	163	163	163	163
	42.5	9⅞	9/16	8.07	12.29	1.99	184	184	184	184
	47.5	10	⅝	8.11	13.70	2.00	206	206	206	206
$H\frac{8}{6.5}$	23.5	7¾	⅜	6.50	6.72	1.58	101	101	100	96
	27.0	7⅞	7/16	6.53	7.76	1.60	116	116	116	111
	30.5	8	½	6.56	8.82	1.62	132	132	132	127
	34.5	8⅛	9/16	6.60	9.97	1.63	150	150	150	144
H6	20.0	6	⅜	6.00	5.81	1.50	87	87	85	81
	23.0	6⅛	7/16	6.02	6.69	1.52	100	100	99	94
	26.5	6¼	½	6.06	7.69	1.53	115	115	114	108
	30.0	6⅜	9/16	6.10	8.70	1.55	131	131	129	123
	33.5	6½	⅝	6.14	9.72	1.56	146	146	145	138
	37.0	6⅝	11/16	6.18	10.76	1.57	161	161	160	153
	40.5	6¾	¾	6.22	11.80	1.58	177	177	176	169

Columns not secured against yielding sideways and free to fail in the direction of the least Radius of Gyration. For detail dimensions, see pages 64 and 66.

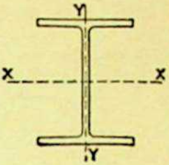
SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

BETHLEHEM COLUMNS.

SUPPLEMENTARY SECTIONS.

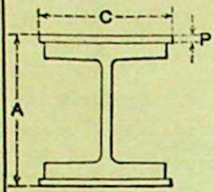
Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\, r^2}}$$ **for lengths over 60 radii.**



UNSUPPORTED LENGTH OF COLUMN, IN FEET.								BENDING FACTORS.		Weight per Foot, Pounds.
10	12	14	16	18	20	22	24	AXIS X-X. k	AXIS Y-Y. k′	
180	167	153	140	128	116	105	. .	.207	1.127	43.0
204	189	173	159	145	132	120	. .	.207	1.118	48.0
227	210	193	177	162	147	134	. .	.207	1.110	53.5
250	232	214	196	179	163	149	135	.207	1.102	58.5
239	239	226	213	199	186	173	161	.199	.857	55.0
266	266	252	237	222	207	193	179	.199	.850	61.5
293	293	279	262	245	229	213	198	.200	.844	67.5
321	321	306	287	269	252	235	218	.200	.838	73.5
301	301	301	292	278	264	250	236	.194	.689	69.0
331	331	331	323	307	292	276	261	.194	.683	76.0
362	362	362	353	336	320	303	286	.194	.678	83.0
393	393	393	384	366	348	330	312	.194	.674	90.0
171	158	146	134	122	111	101	92	.237	1.081	40.5
193	179	165	152	139	127	116	105	.237	1.071	45.5
215	200	185	170	155	142	129	118	.237	1.063	50.5
238	221	204	188	172	157	143	131	.238	1.055	55.0
227	227	216	203	190	178	166	154	.229	.826	52.5
252	252	241	227	213	199	186	173	.229	.819	58.0
278	278	267	251	236	220	206	192	.229	.813	64.0
305	305	292	275	258	242	226	210	.229	.807	70.0
143	133	122	112	103	94	86	78	.278	1.050	33.5
163	151	140	128	118	107	98	90	.276	1.031	38.0
184	171	158	146	134	122	112	102	.277	1.022	42.5
206	191	177	163	150	137	125	115	.277	1.013	47.5
92	83	74	66	59	. .	. .	. .	.349	1.298	23.5
106	96	87	78	69	62	. .	. .	.347	1.270	27.0
122	110	99	89	86	72	. .	. .	.345	1.248	30.5
138	125	113	101	91	81	. .	. .	.345	1.236	34.5
77	69	62	55	49	. .	. .	. .	.451	1.340	20.0
89	80	72	64	57	. .	. .	. .	.446	1.305	23.0
103	93	83	74	66	. .	. .	. .	.445	1.290	26.5
117	106	95	85	75	. .	. .	. .	.445	1.277	30.0
132	119	106	95	85	. .	. .	. .	.444	1.264	33.5
146	132	118	106	94	. .	. .	. .	.443	1.251	37.0
161	145	130	117	104	. .	. .	. .	.442	1.240	40.5

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

REINFORCED 14″ H COLUMNS.

BETHLEHEM 14″ H COLUMNS WITH COVER PLATES.

Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

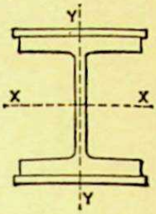
Section Reinforced.	Weight of Column per Foot, Pounds.	DIMENSIONS, INCHES. C	P	A	Area of Column, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET. 16	18	20	22
H14 254.0 Lbs. per Foot.	294.8	16	3/8	17 1/8	86.43	3.89	1296	1296	1284	1239
	301.6	16	7/16	17 1/4	88.43	3.91	1326	1326	1316	1270
	308.4	16	1/2	17 3/8	90.43	3.93	1356	1356	1348	1301
	315.2	16	9/16	17 1/2	92.43	3.94	1386	1386	1379	1332
	322.0	16	5/8	17 5/8	94.43	3.96	1416	1416	1412	1363
	328.8	16	11/16	17 3/4	96.43	3.97	1446	1446	1443	1393
	335.6	16	3/4	17 7/8	98.43	3.99	1476	1476	1475	1425
	342.4	16	13/16	18	100.43	4.00	1506	1506	1506	1456
	349.2	16	7/8	18 1/8	102.43	4.01	1536	1536	1536	1486
	356.0	16	15/16	18 1/4	104.43	4.03	1566	1566	1566	1518
H14 288.5 Lbs. per Foot.	360.8	17	5/8	18 1/8	105.75	4.06	1586	1586	1586	1541
	368.0	17	11/16	18 1/4	107.87	4.07	1618	1618	1618	1574
	375.2	17	3/4	18 3/8	110.00	4.09	1650	1650	1650	1608
	382.4	17	13/16	18 1/2	112.12	4.11	1682	1682	1682	1642
	389.7	17	7/8	18 5/8	114.25	4.12	1714	1714	1714	1675
	396.9	17	15/16	18 3/4	116.37	4.14	1746	1746	1746	1709
	404.1	17	1	18 7/8	118.50	4.15	1778	1778	1778	1742
	411.3	17	1 1/16	19	120.62	4.17	1809	1809	1809	1776
	418.6	17	1 1/8	19 1/8	122.75	4.18	1841	1841	1841	1809
H14 288.5 Lbs. per Foot.	426.2	18	1 1/8	19 1/8	125.00	4.31	1875	1875	1875	1862
	433.9	18	1 3/16	19 1/4	127.25	4.33	1909	1909	1909	1898
	441.5	18	1 1/4	19 3/8	129.50	4.34	1943	1943	1943	1933
	449.2	18	1 5/16	19 1/2	131.75	4.36	1976	1976	1976	1970
	456.8	18	1 3/8	19 5/8	134.00	4.37	2010	2010	2010	2005
	464.5	18	1 7/16	19 3/4	136.25	4.39	2044	2044	2044	2042
	472.1	18	1 1/2	19 7/8	138.50	4.40	2078	2078	2078	2078
	479.8	18	1 9/16	20	140.75	4.42	2111	2111	2111	2111
	487.4	18	1 5/8	20 1/8	143.00	4.43	2145	2145	2145	2145
	495.1	18	1 11/16	20 1/4	145.25	4.44	2179	2179	2179	2179
	502.7	18	1 3/4	20 3/8	147.50	4.46	2213	2213	2213	2213

For detail dimensions see page 70.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

REINFORCED 14″ H COLUMNS.

BETHLEHEM 14″ H COLUMNS
WITH COVER PLATES.

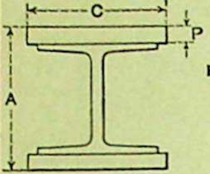


Allowable Stress in Pounds per Square Inch:
15,000 for lengths under 60 radii.

$$\frac{18{,}000}{1+\frac{l^2}{18{,}000\,r^2}}$$ **for lengths over 60 radii.**

UNSUPPORTED LENGTH OF COLUMN, IN FEET.									BENDING FACTORS.		Weight of Column per Foot, Pounds.
24	26	28	30	32	36	40	44	48	AXIS X-X. k	AXIS Y-Y. k′	
1193	1146	1100	1054	1009	923	843	769	701	.180	.528	294.8
1223	1176	1129	1082	1036	948	866	791	722	.179	.523	301.6
1254	1206	1158	1110	1064	974	890	813	742	.178	.519	308.4
1283	1234	1185	1137	1089	998	912	833	761	.178	.515	315.2
1314	1264	1214	1165	1116	1023	936	855	781	.177	.510	322.0
1343	1292	1242	1191	1142	1047	958	875	800	.176	.507	328.8
1374	1322	1271	1220	1170	1073	982	898	821	.175	.503	335.6
1404	1351	1299	1247	1196	1097	1004	919	840	.174	.500	342.4
1433	1380	1326	1273	1222	1121	1027	939	859	.174	.496	349.2
1464	1410	1356	1302	1249	1147	1051	962	880	.173	.493	356.0
1488	1433	1379	1325	1272	1169	1071	981	899	.175	.517	360.8
1519	1464	1408	1353	1299	1194	1095	1003	919	.175	.512	368.0
1552	1496	1440	1384	1329	1222	1122	1028	942	.174	.508	375.2
1586	1529	1472	1415	1359	1251	1148	1053	965	.173	.504	382.4
1617	1560	1502	1444	1387	1277	1172	1075	986	.172	.500	389.7
1651	1592	1534	1475	1417	1305	1199	1100	1009	.171	.496	396.9
1683	1623	1564	1504	1445	1331	1224	1123	1030	.171	.492	404.1
1716	1656	1596	1535	1476	1360	1251	1148	1054	.170	.489	411.3
1748	1687	1626	1565	1504	1387	1275	1171	1075	.169	.486	418.6
1803	1743	1682	1622	1561	1444	1332	1227	1129	.168	.485	426.2
1839	1778	1716	1655	1594	1475	1361	1254	1155	.167	.481	433.9
1873	1811	1749	1686	1624	1503	1388	1279	1178	.166	.477	441.5
1909	1846	1783	1720	1657	1535	1417	1307	1204	.166	.474	449.2
1943	1880	1816	1752	1688	1563	1444	1332	1227	.165	.471	456.8
1979	1915	1850	1785	1721	1595	1474	1360	1254	.164	.467	464.5
2014	1949	1883	1817	1752	1624	1501	1385	1277	.164	.464	472.1
2050	1984	1918	1851	1785	1655	1531	1413	1304	.163	.461	479.8
2085	2018	1951	1883	1816	1684	1558	1439	1327	.163	.459	487.4
2119	2052	1983	1915	1847	1713	1585	1464	1351	.162	.456	495.1
2156	2087	2019	1949	1881	1745	1615	1493	1378	.161	.453	502.7

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.



SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

SPECIAL COMPOUND COLUMNS.

BETHLEHEM 14⅛" x 149 LBS. SPECIAL H SECTION REINFORCED WITH COVER PLATES.

Allowable Stress in Pounds per Square Inch:

15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

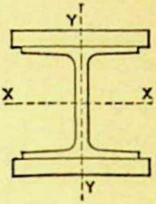
Section of Column.	Weight of Column, per Foot, Pounds.	DIMENSIONS, INCHES.			Area of Column, Square Inches.	Least Radius of Gyration, Inches.	UNSUPPORTED LENGTH OF COLUMN, IN FEET.			
		C	P	A			16	18	20	22
Columns composed of a 14⅛ x 149 Lbs. Special H Section (Section H14b), reinforced with cover plates of width and thickness given in table.	285.0	16	1 1/4	16 5/8	83.52	3.98	1253	1253	1251	1208
	291.8	16	1 5/16	16 3/4	85.52	3.99	1283	1283	1282	1238
	298.6	16	1 3/8	16 7/8	87.52	4.01	1313	1313	1313	1270
	305.4	16	1 7/16	17	89.52	4.02	1343	1343	1343	1300
	312.2	16	1 1/2	17 1/8	91.52	4.04	1373	1373	1373	1331
	319.0	16	1 9/16	17 1/4	93.52	4.05	1403	1403	1403	1362
	325.8	16	1 5/8	17 3/8	95.52	4.06	1433	1433	1433	1392
	332.6	16	1 11/16	17 1/2	97.52	4.08	1463	1463	1463	1424
	339.4	16	1 3/4	17 5/8	99.52	4.09	1493	1493	1493	1455
	346.2	16	1 13/16	17 3/4	101.52	4.10	1523	1523	1523	1485
	351.3	17	1 3/4	17 5/8	103.02	4.30	1545	1545	1545	1533
	358.5	17	1 13/16	17 3/4	105.15	4.31	1577	1577	1577	1566
	365.7	17	1 7/8	17 7/8	107.27	4.32	1609	1609	1609	1599
	373.0	17	1 15/16	18	109.40	4.33	1641	1641	1641	1632
	380.2	17	2	18 1/8	111.52	4.35	1673	1673	1673	1666
	387.4	17	2 1/16	18 1/4	113.65	4.36	1705	1705	1705	1700
	394.6	17	2 1/8	18 3/8	115.77	4.37	1737	1737	1737	1733
	401.9	17	2 3/16	18 1/2	117.90	4.38	1769	1769	1769	1766
	409.1	17	2 1/4	18 5/8	120.02	4.39	1800	1800	1800	1799
	416.3	17	2 5/16	18 3/4	122.15	4.40	1832	1832	1832	1832
	424.4	18	2 1/4	18 5/8	124.52	4.62	1868	1868	1868	1868
	432.0	18	2 5/16	18 3/4	126.77	4.63	1902	1902	1902	1902
	439.7	18	2 3/8	18 7/8	129.02	4.64	1935	1935	1935	1935
	447.3	18	2 7/16	19	131.27	4.65	1969	1969	1969	1969
	455.0	18	2 1/2	19 1/8	133.52	4.66	2003	2003	2003	2003
	462.6	18	2 9/16	19 1/4	135.77	4.67	2037	2037	2037	2037
	470.3	18	2 5/8	19 3/8	138.02	4.68	2070	2070	2070	2070
	477.9	18	2 11/16	19 1/2	140.27	4.69	2104	2104	2104	2104
	485.6	18	2 3/4	19 5/8	142.52	4.70	2138	2138	2138	2138
	493.2	18	2 13/16	19 3/4	144.77	4.70	2172	2172	2172	2172
	500.9	18	2 7/8	19 7/8	147.02	4.71	2205	2205	2205	2205

For detail dimensions see page 72.

SAFE LOADS, IN THOUSANDS OF POUNDS, FOR

SPECIAL COMPOUND COLUMNS.

BETHLEHEM 14⅜″ x 149 Lbs. SPECIAL H SECTION REINFORCED WITH COVER PLATES.



Allowable Stress in Pounds per Square Inch:

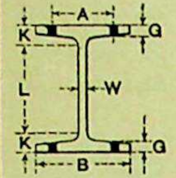
15,000 for lengths under 60 radii.

$$\frac{18,000}{1+\frac{l^2}{18,000\,r^2}}$$ **for lengths over 60 radii.**

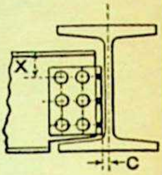
UNSUPPORTED LENGTH OF COLUMN, IN FEET.									BENDING FACTORS.		Weight of Column per Foot, Pounds.
24	26	28	30	32	36	40	44	48	AXIS X-X. k	AXIS Y-Y. k′	
1165	1121	1077	1034	991	909	831	760	695	.186	.505	285.0
1194	1149	1104	1060	1016	932	853	780	713	.185	.501	291.8
1224	1179	1133	1088	1044	958	877	802	734	.184	.498	298.6
1254	1207	1161	1115	1069	982	899	823	753	.183	.494	305.4
1285	1237	1190	1143	1097	1007	923	845	774	.182	.491	312.2
1314	1266	1218	1170	1123	1031	946	866	793	.181	.487	319.0
1344	1295	1245	1197	1149	1056	968	886	812	.180	.484	325.8
1375	1325	1275	1225	1176	1082	992	909	833	.179	.481	332.6
1404	1354	1303	1252	1202	1106	1015	930	852	.179	.479	339.4
1434	1383	1331	1279	1229	1130	1037	951	872	.178	.476	346.2
1484	1435	1385	1335	1285	1188	1096	1009	929	.177	.460	351.3
1517	1466	1415	1364	1313	1215	1121	1032	950	.176	.458	358.5
1549	1497	1445	1393	1342	1241	1145	1055	971	.175	.455	365.7
1581	1528	1476	1423	1370	1268	1170	1078	993	.175	.452	373.0
1614	1561	1508	1454	1401	1297	1197	1104	1017	.174	.450	380.2
1647	1593	1538	1484	1430	1324	1223	1127	1039	.173	.448	387.4
1679	1624	1569	1513	1458	1351	1248	1151	1060	.173	.446	394.6
1711	1656	1599	1543	1487	1378	1273	1174	1082	.172	.443	401.9
1743	1687	1630	1573	1516	1405	1298	1198	1104	.171	.441	409.1
1776	1719	1661	1603	1545	1432	1324	1222	1126	.171	.440	416.3
1843	1788	1732	1676	1620	1509	1401	1299	1203	.170	.422	424.4
1878	1822	1765	1708	1651	1538	1429	1325	1227	.169	.420	432.0
1913	1856	1798	1740	1682	1567	1456	1351	1251	.169	.418	439.7
1948	1890	1832	1773	1714	1597	1484	1377	1276	.168	.416	447.3
1983	1924	1865	1805	1745	1627	1512	1403	1300	.167	.415	455.0
2018	1958	1898	1837	1777	1656	1540	1429	1324	.167	.413	462.6
2053	1992	1931	1870	1808	1686	1568	1455	1349	.166	.411	470.3
2088	2027	1965	1902	1840	1716	1596	1482	1374	.166	.410	477.9
2123	2061	1998	1935	1871	1746	1624	1508	1398	.165	.408	485.6
2156	2093	2030	1965	1901	1773	1650	1532	1421	.164	.407	493.2
2191	2128	2063	1998	1933	1803	1678	1558	1445	.164	.406	500.9

Loads to the right of the heavy line are for lengths greater than 120 radii.
Bending Factors are explained on pages 39 and 99.

BETHLEHEM GIRDER BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES



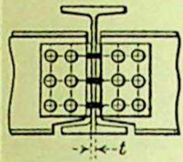
Section Number.	Depth of Beam, Ins.	Weight per Foot, Lbs.	DIMENSIONS, IN INCHES.									
			Flange.	Web.	TANGENT DISTANCE.		RIVET DISTANCE.		Grip.	Gage.	Maximum Rivet in Fl'ge.	Framing Distance.
			B	W	L	K	Min. X	Max. X	G	A		C
	30 1/8	200.0	15 1/32	3/4	25 1/2	2 5/16	3 9/16	5 9/16	1 5/32	10	1	7/16
G30	30	190.0	15	23/32	25 1/2	2 1/4	3 1/2	5 1/2	1 3/32	10	1	7/16
	29 7/8	181.0	14 31/32	11/16	25 1/2	2 3/16	3 7/16	5 7/16	1 1/32	10	1	7/16
G28	28 1/8	175.0	14 9/32	11/16	23 3/4	2 3/16	3 7/16	6 11/16	1 1/16	10	1	7/16
	28	165.0	14 1/4	21/32	23 3/4	2 1/8	3 3/8	6 5/8	1	10	1	3/8
	26 1/8	160.0	13 25/32	21/32	22	2 1/16	3 5/16	4 13/16	1	10	1	3/8
G26	26	151.0	13 3/4	5/8	22	2	3 1/4	4 3/4	15/16	10	1	3/8
	25 7/8	144.0	13 23/32	5/8	22	1 15/16	3 3/16	4 11/16	7/8	10	1	3/8

The depths of beams are given as used for detailing.

ALLOWABLE STRESSES IN RIVETS.

Shop Rivets	Shearing:	13,500 pounds per square inch.
	Bearing:	27,000 pounds per square inch.
Field Rivets	Shearing:	12,000 pounds per square inch.
	Bearing:	24,000 pounds per square inch.

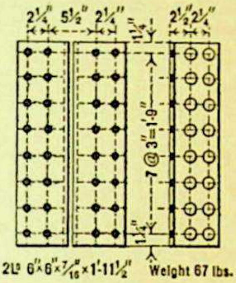
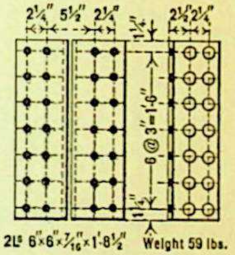
BETHLEHEM GIRDER BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.

For Connection Angles, all open holes are 13/16 inch in diameter and all rivets or bolts are 3/4 inch in diameter.

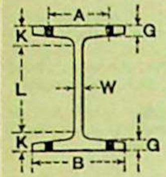
Weights given are for one connection exclusive of rivet heads.

Maximum Reaction, in Thousands of Pounds.	Least Span, in Feet.	Least Web Thickness, Inches. t		Section Number.
170	21.5	19/32	 2Ls 6"×6"×7/16"×1'-11½" Weight 67 lbs.	G30
170	20.4	19/32		
170	19.4	19/32		
148	20.1	19/32	 2Ls 6"×6"×7/16"×1'-8½" Weight 59 lbs.	G28
148	19.0	19/32		
148	17.3	19/32		G26
148	16.3	19/32		
143	16.0	9/16		

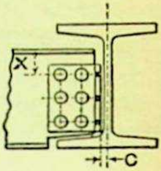
The Maximum Reaction and the corresponding Least Span for safe uniform load are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web. Least spans for the above and other conditions are given on pages 136 to 139. For notes and tables relating to web strength, see pages 93 to 96.

The Least Web Thickness, t, of the supporting member between two equal beams framing opposite each other, is determined by the Maximum Reaction and the bearing on the field rivets.

BETHLEHEM GIRDER BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.



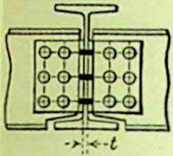
Section Number.	Depth of Beam, Ins.	Weight per Foot, Lbs.	DIMENSIONS, IN INCHES.									
			Flange.	Web.	TANGENT DISTANCE.		RIVET DISTANCE.		Grip.	Gage.	Maximum Rivet in Fl'ge.	Framing Distance.
			B	W	L	K	Min. X	Max. X	G	A		C
	$24\frac{1}{8}$	149.0	$13\frac{9}{32}$	$\frac{21}{32}$	$20\frac{1}{8}$	2	$3\frac{1}{4}$	$5\frac{7}{8}$	$1\frac{3}{32}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
G24a	24	141.0	$13\frac{1}{4}$	$\frac{5}{8}$	$20\frac{1}{8}$	$1\frac{15}{16}$	$3\frac{3}{16}$	$5\frac{13}{16}$	$1\frac{1}{32}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
	$23\frac{7}{8}$	133.0	$13\frac{7}{32}$	$\frac{19}{32}$	$20\frac{1}{8}$	$1\frac{7}{8}$	$3\frac{1}{8}$	$5\frac{3}{4}$	$\frac{31}{32}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
	$24\frac{1}{8}$	129.0	$12\frac{9}{32}$	$\frac{19}{32}$	$20\frac{3}{8}$	$1\frac{7}{8}$	$3\frac{1}{8}$	6	$\frac{31}{32}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
G24	24	121.0	$12\frac{1}{4}$	$\frac{17}{32}$	$20\frac{3}{8}$	$1\frac{13}{16}$	$3\frac{1}{16}$	$5\frac{15}{16}$	$\frac{29}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$
	$23\frac{7}{8}$	114.0	$12\frac{7}{32}$	$\frac{1}{2}$	$20\frac{3}{8}$	$1\frac{3}{4}$	3	$5\frac{7}{8}$	$\frac{27}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$
	$20\frac{1}{8}$	149.0	$12\frac{25}{32}$	$\frac{11}{16}$	$15\frac{3}{4}$	$2\frac{3}{16}$	$3\frac{7}{16}$	$4\frac{11}{16}$	$1\frac{3}{16}$	$7\frac{1}{2}$	1	$\frac{7}{16}$
G20a	20	142.0	$12\frac{3}{4}$	$\frac{21}{32}$	$15\frac{3}{4}$	$2\frac{1}{8}$	$3\frac{3}{8}$	$4\frac{5}{8}$	$1\frac{1}{8}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
	$19\frac{7}{8}$	135.0	$12\frac{23}{32}$	$\frac{5}{8}$	$15\frac{3}{4}$	$2\frac{1}{16}$	$3\frac{5}{16}$	$4\frac{9}{16}$	$1\frac{1}{16}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
	$20\frac{1}{8}$	120.0	$12\frac{1}{32}$	$\frac{19}{32}$	$16\frac{3}{8}$	$1\frac{7}{8}$	$3\frac{1}{8}$	5	$\frac{31}{32}$	$7\frac{1}{2}$	1	$\frac{3}{8}$
G20	20	113.0	12	$\frac{9}{16}$	$16\frac{3}{8}$	$1\frac{13}{16}$	$3\frac{1}{16}$	$4\frac{15}{16}$	$\frac{29}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$
	$19\frac{7}{8}$	107.0	$11\frac{31}{32}$	$\frac{17}{32}$	$16\frac{3}{8}$	$1\frac{3}{4}$	3	$4\frac{7}{8}$	$\frac{27}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$
	$18\frac{1}{8}$	100.0	$11\frac{17}{32}$	$\frac{17}{32}$	$14\frac{3}{4}$	$1\frac{11}{16}$	$2\frac{15}{16}$	$3\frac{3}{16}$	$\frac{27}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$
G18	18	93.0	$11\frac{1}{2}$	$\frac{15}{32}$	$14\frac{3}{4}$	$1\frac{5}{8}$	$2\frac{7}{8}$	$3\frac{1}{8}$	$\frac{25}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$
	$17\frac{7}{8}$	87.5	$11\frac{15}{32}$	$\frac{15}{32}$	$14\frac{3}{4}$	$1\frac{9}{16}$	$2\frac{13}{16}$	$3\frac{1}{16}$	$\frac{23}{32}$	$7\frac{1}{2}$	1	$\frac{5}{16}$

The depths of beams are given as used for detailing.

ALLOWABLE STRESSES IN RIVETS.

Shop Rivets	Shearing:	13,500 pounds per square inch.
	Bearing:	27,000 pounds per square inch.
Field Rivets	Shearing:	12,000 pounds per square inch.
	Bearing:	24,000 pounds per square inch.

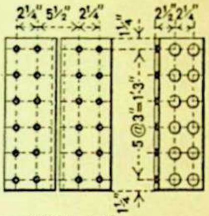
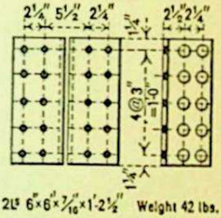
BETHLEHEM GIRDER BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.

For Connection Angles, all open holes are 13/16-inch in diameter and all rivets or bolts are ¾ inch in diameter.

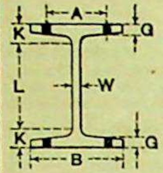
Weights given are for one connection exclusive of rivet heads.

Maximum Reaction, in Thousands of Pounds.	Least Span, in Feet.	Least Web Thickness, Inches. t		Section Number.
127	17.4	19/32	 2Ls 6"×6"×7/16"×1'-5½" Weight 50 lbs.	G24a
127	16.4	19/32		
127	15.5	19/32		
127	15.0	19/32		G24
114	15.7	17/32		
103	16.3	15/32		
106	17.5	19/32	 2Ls 6"×6"×7/16"×1'-2½" Weight 42 lbs.	G20a
106	16.6	19/32		
106	15.7	19/32		
106	14.1	19/32		G20
106	13.2	19/32		
106	12.4	19/32		
97	11.8	17/32		G18
86	12.4	15/32		
80	12.4	7/16		

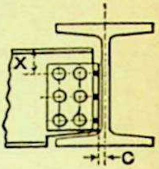
The Maximum Reaction and the corresponding Least Span for safe uniform load are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web. Least spans for the above and other conditions are given on pages 136 to 139. For notes and tables relating to web strength, see pages 93 to 96.

The Least Web Thickness, t, of the supporting member between two equal beams framing opposite each other, is determined by the Maximum Reaction and the bearing on the field rivets.

BETHLEHEM GIRDER BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES



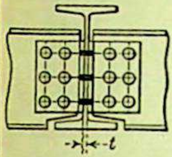
Section Number.	Depth of Beam, Ins.	Weight per Foot, Lbs.	DIMENSIONS, IN INCHES.									
			Flange.	Web.	TANGENT DISTANCE.		RIVET DISTANCE.		Grip.	Gage.	Maximum Rivet in Fl'ge.	Framing Distance.
			B	W	L	K	Min. X	Max. X	G	A		C
G15b	15 1/8	147.0	11 25/32	27/32	10 1/4	2 7/16	3 11/16	......	1 5/16	7 1/2	1	1/2
	15	141.0	11 3/4	13/16	10 1/4	2 3/8	3 5/8	......	1 9/32	7 1/2	1	7/16
	14 7/8	135.0	11 23/32	25/32	10 1/4	2 5/16	3 9/16	......	1 7/32	7 1/2	1	7/16
G15a	15 1/8	111.0	11 9/32	5/8	11 1/4	1 15/16	3 3/16	3 3/16	1	7 1/2	1	3/8
	15	105.0	11 1/4	19/32	11 1/4	1 7/8	3 1/8	3 1/8	15/16	7 1/2	1	3/8
	14 7/8	99.0	11 7/32	9/16	11 1/4	1 13/16	3 1/16	3 1/16	7/8	7 1/2	1	3/8
G15	15 1/8	80.5	10 25/32	15/32	12 1/8	1 1/2	2 3/4	3 3/8	23/32	7 1/2	1	5/16
	15	74.0	10 3/4	7/16	12 1/8	1 7/16	2 11/16	3 5/16	21/32	7 1/2	1	5/16
	14 7/8	69.0	10 23/32	13/32	12 1/8	1 3/8	2 5/8	3 1/4	19/32	7 1/2	1	1/4
G12a	12 1/8	76.5	10 9/32	1/2	9	1 9/16	2 13/16	3 5/16	13/16	5 1/2	1	5/16
	12	70.5	10 1/4	15/32	9	1 1/2	2 3/4	3 1/4	3/4	5 1/2	1	5/16
	11 7/8	66.0	10 7/32	7/16	9	1 7/16	2 11/16	3 3/16	11/16	5 1/2	1	5/16
G12	12 1/8	61.0	10 1/32	13/32	9 1/2	1 5/16	2 9/16	3 9/16	21/32	5 1/2	1	1/4
	12	55.5	10	3/8	9 1/2	1 1/4	2 1/2	3 1/2	19/32	5 1/2	1	1/4
	11 7/8	51.5	9 31/32	3/8	9 1/2	1 3/16	2 7/16	3 7/16	9/16	5 1/2	1	1/4
G10	10 1/8	50.0	9 1/32	3/8	7 3/4	1 3/16	2 7/16	4 11/16	19/32	5 1/2	7/8	1/4
	10	44.5	9	5/16	7 3/4	1 1/8	2 3/8	4 5/8	17/32	5 1/2	7/8	1/4
	9 7/8	41.5	9	5/16	7 3/4	1 1/16	2 5/16	4 9/16	1/2	5 1/2	7/8	3/16
G9	9 1/8	43.5	8 17/32	11/32	6 7/8	1 1/8	2 3/8	3 3/4	17/32	5 1/2	7/8	1/4
	9	38.5	8 1/2	5/16	6 7/8	1 1/16	2 5/16	3 11/16	15/32	5 1/2	7/8	3/16
	8 15/16	36.0	8 15/32	9/32	6 7/8	1 1/16	2 5/16	3 5/8	7/16	5 1/2	7/8	3/16
G8	8 1/8	37.0	8 1/32	11/32	6	1 1/16	2 5/16	2 13/16	15/32	5 1/2	7/8	1/4
	8	33.0	8	5/16	6	1	2 1/4	2 3/4	13/32	5 1/2	7/8	3/16
	7 15/16	31.0	8	9/32	6	1	2 1/4	2 11/16	3/8	5 1/2	7/8	3/16

The depths of beams are given as used for detailing.

ALLOWABLE STRESSES IN RIVETS.

Shop Rivets	Shearing:	13,500 pounds per square inch.
	Bearing:	27,000 pounds per square inch.
Field Rivets	Shearing:	12,000 pounds per square inch.
	Bearing:	24,000 pounds per square inch.

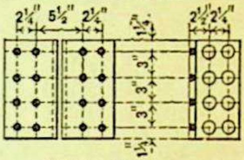
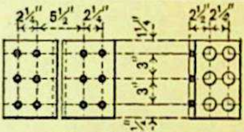
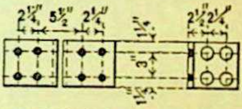
BETHLEHEM GIRDER BEAMS.



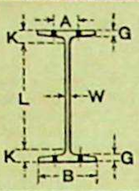
DETAIL DIMENSIONS AND CONNECTION ANGLES.

For Connection Angles, all open holes are 13/16 inch in diameter and all rivets or bolts are ¾ inch in diameter.

Weights given are for one connection exclusive of rivet heads.

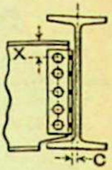
Maximum Reaction, in Thousands of Pounds.	Least Span, in Feet.	Least Web Thickness, Inches. t		Section Number.
85	15.6	19/32	SPECIAL CONNECTION TO BE USED. VALUES GIVEN ARE FOR 8 RIVETS IN WEB AND 16 FIELD RIVETS.	G15b
85	14.9	19/32		
85	14.2	19/32		
85	12.2	19/32	 $2L^s$ 6"×6"×7/16"×0'-11½" Weight 33 lbs.	G15a
85	11.5	19/32		
85	10.8	19/32		
78	9.9	17/32		G15
69	10.3	15/32		
64	10.2	7/16		
62	9.4	9/16	 $2L^s$ 6"×6"×7/16"×0'-8½" Weight 24 lbs.	G12a
57	9.4	17/32		
55	9.1	1/2		
50	9.5	15/32		G12
46	9.4	7/16		
44	9.1	13/32		
29	11.2	13/32	 $2L^s$ 6"×6"×7/16"×0'-5½" Weight 16 lbs.	G10
26	11.3	3/8		
25	10.8	11/32		
28	9.0	13/32		G9
25	9.0	11/32		
23	9.1	5/16		
27	7.3	3/8		G8
24	7.0	11/32		
23	6.8	5/16		

The Maximum Reaction and the corresponding Least Span for safe uniform load are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web. Least spans for the above and other conditions are given on pages 136 to 139. For notes and tables relating to web strength, see pages 93 to 96. The Least Web Thickness, t, of the supporting member between two equal beams framing opposite each other, is determined by the Maximum Reaction and the bearing on the field rivets.



BETHLEHEM I BEAMS.

DETAIL DIMENSIONS AND CONNECTION ANGLES.

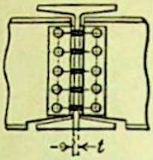


Section Number.	Depth of Beam, Ins.	Weight per Foot, Lbs.	DIMENSIONS, IN INCHES.									
			Flange.	Web.	TANGENT DISTANCE.		RIVET DISTANCE.		Grip.	Gage.	Maximum Rivet in Fl'ge.	Framing Distance.
			B	W	L	K	Min. X	Max. X	G	A		C
B30	30 1/8	129.0	10 17/32	19/32	26 1/2	1 13/16	3 1/16	3 1/16	1	5 1/2	1	3/8
	30	121.0	10 1/2	9/16	26 1/2	1 3/4	3	3	15/16	5 1/2	1	5/16
	29 7/8	115.0	10 15/32	17/32	26 1/2	1 11/16	2 15/16	2 15/16	7/8	5 1/2	1	5/16
B28	28 1/8	113.0	10 1/32	17/32	24 3/4	1 11/16	2 15/16	4 3/16	15/16	5 1/2	1	5/16
	28	106.0	10	1/2	24 3/4	1 5/8	2 7/8	4 1/8	7/8	5 1/2	1	5/16
	27 7/8	100.0	9 31/32	1/2	24 3/4	1 9/16	2 13/16	4 1/16	13/16	5 1/2	1	5/16
B26	26 1/8	98.0	9 17/32	1/2	23	1 9/16	2 13/16	5 5/16	27/32	5 1/2	1	5/16
	26	91.0	9 1/2	15/32	23	1 1/2	2 3/4	5 1/4	25/32	5 1/2	1	5/16
	25 7/8	85.5	9 15/32	7/16	23	1 7/16	2 11/16	5 3/16	23/32	5 1/2	1	5/16
B24b	24 1/8	104.5	9 25/32	9/16	20 3/4	1 11/16	2 15/16	3 3/16	15/16	5 1/2	7/8	5/16
	24	99.5	9 3/4	17/32	20 3/4	1 5/8	2 7/8	3 1/8	7/8	5 1/2	7/8	5/16
	23 7/8	95.5	9 23/32	1/2	20 3/4	1 9/16	2 13/16	3 1/16	27/32	5 1/2	7/8	5/16
B24a	24	84.5	9 1/2	15/32	21 1/8	1 7/16	2 11/16	3 5/16	13/16	4	7/8	5/16
B24	24 1/8	79.5	9 1/32	7/16	21 3/8	1 3/8	2 5/8	3 1/2	25/32	4	7/8	1/4
	24	73.5	9	13/32	21 3/8	1 5/16	2 9/16	3 7/16	23/32	4	7/8	1/4

The depths of beams are given as used for detailing.

ALLOWABLE STRESSES IN RIVETS.

Shop Rivets	Shearing:	13,500 pounds per square inch.
	Bearing:	27,000 pounds per square inch.
Field Rivets	Shearing:	12,000 pounds per square inch.
	Bearing:	24,000 pounds per square inch.

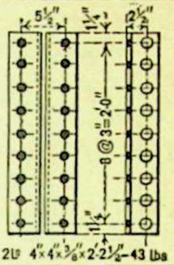
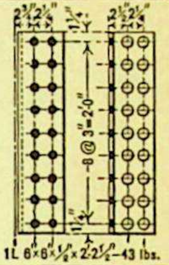
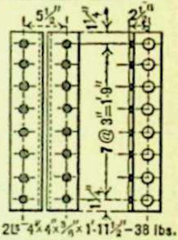
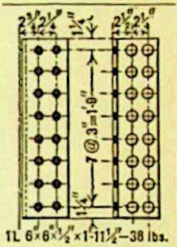
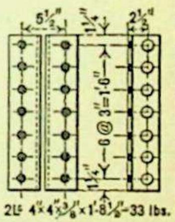
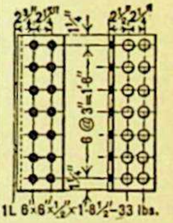


BETHLEHEM I BEAMS.

DETAIL DIMENSIONS AND CONNECTION ANGLES.

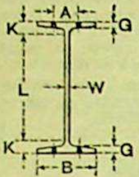
For Connection Angles, all open holes are 13/16 inch in diameter and all rivets or bolts are ¾ inch in diameter.

Weights given are for one connection exclusive of rivet heads.

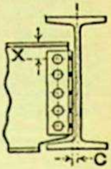
Maximum Reaction, in Thousands of Pounds.	Least Span, in Feet.	Least Web Thickness, Inches. t	DOUBLE.	SINGLE.	Section Number.
95	23.2	19/32	 2L 4"×4"×⅜"×2'-2½"—43 lbs	 1L 6"×6"×½"×2'-2½"—43 lbs.	B30
95	21.9	19/32			
95	20.6	19/32			
85	21.6	19/32	 2L 4"×4"×⅜"×1'-11½"—38 lbs.	 1L 6"×6"×½"×1'-11½"—38 lbs.	B28
83	20.7	9/16			
79	20.2	9/16			
71	20.7	9/16	 2L 4"×4"×⅜"×1'-8½"—33 lbs.	 1L 6"×6"×½"×1'-8½"—33 lbs.	B26
67	20.5	17/32			
64	19.9	½			
74	19.9	19/32			B24b
74	18.9	19/32			
72	18.7	9/16			
65	18.3	17/32			B24a
61	18.3	15/32			B24
56	18.6	7/16			

The Maximum Reaction and the corresponding Least Span for safe uniform load are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web. Least spans for the above and other conditions are given on pages 136 to 139. For notes and tables relating to web strength, see pages 93 to 96. The Least Web Thickness, t, of the supporting member between two equal beams framing opposite each other, is determined by the Maximum Reaction and the bearing on the field rivets.

BETHLEHEM I BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.



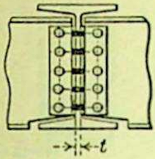
Section Number.	Depth of Beam, Ins.	Weight per Foot, Lbs.	DIMENSIONS, IN INCHES.									
			Flange.	Web.	TANGENT DISTANCE.		RIVET DISTANCE.		Grip.	Gage.	Maximum Rivet in Fl'ge.	Framing Distance.
			B	W	L	K	Min. X	Max. X	G	A		C
	22 1/8	71.5	8 17/32	13/32	19 3/8	1 3/8	2 5/8	4 1/2	23/32	4	7/8	1/4
B22	22 1/16	68.5	8 17/32	13/32	19 3/8	1 5/16	2 9/16	4 1/2	23/32	4	7/8	1/4
	22	65.5	8 1/2	3/8	19 3/8	1 5/16	2 9/16	4 7/16	11/16	4	7/8	1/4
B20a	20 1/8	78.0	8 29/32	15/32	17 1/8	1 1/2	2 3/4	5 3/8	27/32	4	7/8	5/16
	20	73.0	8 7/8	7/16	17 1/8	1 7/16	2 11/16	5 5/16	25/32	4	7/8	1/4
	20 1/8	64.5	8 1/32	13/32	17 5/8	1 1/4	2 1/2	5 5/8	23/32	4	7/8	1/4
B20	20 1/16	62.0	8	3/8	17 5/8	1 1/4	2 1/2	5 9/16	11/16	4	7/8	1/4
	20	59.5	8	3/8	17 5/8	1 3/16	2 7/16	5 9/16	21/32	4	7/8	1/4
	18 1/8	74.0	8 25/32	7/16	15 1/4	1 7/16	2 11/16	3 7/16	27/32	4	7/8	5/16
B18a	18	69.0	8 3/4	13/32	15 1/4	1 3/8	2 5/8	3 3/8	25/32	4	7/8	1/4
	17 7/8	64.5	8 23/32	13/32	15 1/4	1 5/16	2 9/16	3 5/16	23/32	4	7/8	1/4
	18 1/8	54.5	7 17/32	3/8	15 3/4	1 3/16	2 7/16	3 11/16	21/32	3 3/4	7/8	1/4
B18	18 1/16	52.0	7 17/32	11/32	15 3/4	1 1/8	2 3/8	3 11/16	5/8	3 3/4	7/8	1/4
	18	49.0	7 1/2	11/32	15 3/4	1 1/8	2 3/8	3 5/8	19/32	3 3/4	7/8	1/4

The depths of beams are given as used for detailing.

ALLOWABLE STRESSES IN RIVETS.

Shop Rivets	Shearing:	13,500 pounds per square inch.
	Bearing:	27,000 pounds per square inch.
Field Rivets	Shearing:	12,000 pounds per square inch.
	Bearing:	24,000 pounds per square inch.

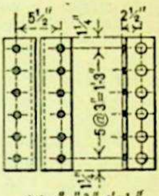
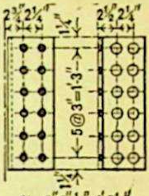
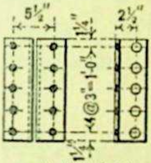
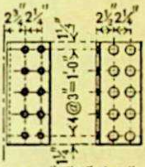
BETHLEHEM I BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.

For Connection Angles, all open holes are 13/16 inch in diameter and all rivets or bolts are ¾ inch in diameter.

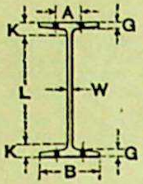
Weights given are for one connection exclusive of rivet heads.

Maximum Reaction, in Thousands of Pounds.	Least Span, in Feet.	Least Web Thickness, Inches. t	DOUBLE.	SINGLE.	Section Number.
51	18.1	15/32	 2L^s 4"×4"×⅜"×1'-5½" Weight 29 Pounds.	 1L 6"×6"×½"×1'-5½" Weight 29 Pounds.	B22
49	18.0	15/32			
47	18.1	7/16			
47	20.1	17/32	 2L^s 4"×4"×⅜"×1'-2½" Weight 24 Pounds.	 1L 6"×6"×½"×1'-2½" Weight 24 Pounds.	B20a
44	20.2	15/32			
41	18.9	7/16			B20
39	18.6	7/16			
38	18.5	13/32			
45	18.4	½			B18a
43	17.9	15/32			
41	17.4	7/16			
37	15.7	13/32			B18
36	15.6	13/32			
33	15.9	⅜			

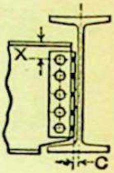
The Maximum Reaction and the corresponding Least Span for safe uniform load are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web. Least spans for the above and other conditions are given on pages 136 to 139. For notes and tables relating to web strength, see pages 93 to 96.

The Least Web Thickness, t, of the supporting member between two equal beams framing opposite each other, is determined by the Maximum Reaction and the bearing on the field rivets.

BETHLEHEM I BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.



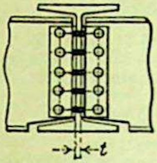
Section Number.	Depth of Beam, Ins.	Weight per Foot, Lbs.	DIMENSIONS, IN INCHES.									
			Flange.	Web.	TANGENT DISTANCE.		RIVET DISTANCE.		Grip.	Gage.	Maximum Rivet in Fl'ge.	Framing Distance.
			B	W	L	K	Min. X	Max. X	G	A		C
B15b	15	71.5	7 1/2	17/32	11 3/4	1 5/8	2 7/8	3 1/8	15/16	3 3/4	7/8	5/16
B15a	15 1/8	59.5	7 1/32	7/16	12 3/8	1 3/8	2 5/8	3 1/2	13/16	3 1/2	7/8	5/16
	15	54.5	7	13/32	12 3/8	1 5/16	2 9/16	3 7/16	3/4	3 1/2	7/8	1/4
	14 7/8	50.5	6 31/32	3/8	12 3/8	1 1/4	2 1/2	3 3/8	11/16	3 1/2	7/8	1/4
B15	15 1/8	42.5	6 25/32	5/16	12 7/8	1 1/8	2 3/8	3 3/4	19/32	3 1/2	7/8	1/4
	15	40.0	6 3/4	5/16	12 7/8	1 1/16	2 5/16	3 11/16	9/16	3 1/2	7/8	3/16
	15	38.5	6 3/4	9/32	12 7/8	1 1/16	2 5/16	3 11/16	17/32	3 1/2	7/8	3/16
B12a	12	36.5	6 3/8	5/16	9 7/8	1 1/16	2 5/16	3 11/16	19/32	3	3/4	3/16
B12	12 1/16	31.0	6 9/32	9/32	10 1/4	15/16	2 3/16	3 7/8	1/2	3	3/4	3/16
	12	28.5	6 1/4	1/4	10 1/4	7/8	2 1/8	3 7/8	15/32	3	3/4	3/16
B10	10 1/8	26.0	5 25/32	9/32	8 3/8	7/8	2 1/8	5	15/32	2 3/4	3/4	3/16
	10	23.5	5 3/4	1/4	8 3/8	13/16	2 1/16	4 15/16	13/32	2 3/4	3/4	3/16
B9	9 1/16	22.0	5 1/2	1/4	7 1/2	3/4	2	4 1/16	13/32	2 1/2	3/4	3/16
	9	20.5	5 1/2	1/4	7 1/2	3/4	2	4	3/8	2 1/2	3/4	3/16
B8	8 1/16	19.0	5 9/32	9/32	6 5/8	3/4	2	3 1/16	3/8	2 1/4	3/4	3/16
	8	17.5	5 1/4	1/4	6 5/8	11/16	1 15/16	3 1/16	11/32	2 1/4	3/4	3/16

The depths of beams are given as used for detailing.

ALLOWABLE STRESSES IN RIVETS.

Shop Rivets	Shearing:	13,500 pounds per square inch.
	Bearing:	27,000 pounds per square inch.
Field Rivets	Shearing:	12,000 pounds per square inch.
	Bearing:	24,000 pounds per square inch.

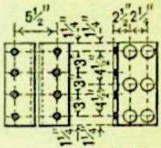
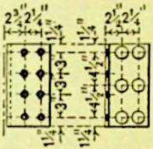
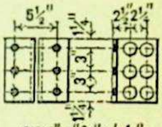
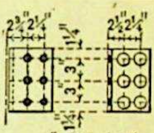
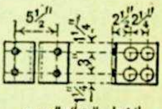
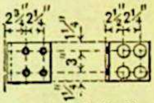
BETHLEHEM I BEAMS.



DETAIL DIMENSIONS AND CONNECTION ANGLES.

For Connection Angles, all open holes are 13/16 inch in diameter and all rivets or bolts are ¾ inch in diameter.

Weights given are for one connection exclusive of rivet heads.

Maximum Reaction, in Thousands of Pounds.	Least Span, in Feet.	Least Web Thickness, Inches. t	DOUBLE.	SINGLE.	Section Number.
42	14.9	19/32	 5½" 1¼" 1¼" 2½" 2¼" 3" 3" 3" 4½" 4½" 1¼" 1¼" 2Ls 6"×4"×⅜"×0'-11½" Weight 24 Pounds.	 2¾" 2¼" 1¼" 1¼" 2½" 2¼" 3" 3" 3" 4½" 4½" 1¼" 1¼" 1L 6"×6"×½"×0'-11½" Weight 19 Pounds.	B15b
42	12.5	19/32			B15a
42	11.5	19/32			
42	10.6	19/32			
39	9.8	9/16			B15
37	9.9	½			
34	10.5	15/32			
32	8.5	19/32	 2Ls 6"×4"×⅜"×0'-8½" Weight 17 Pounds.	 1L 6"×6"×½"×0'8½" Weight 14 Pounds.	B12a
29	8.1	17/32			B12
25	8.7	15/32			
21	7.7	19/32	 2Ls 6"×4"×⅜"×0'-5½" Weight 11 Pounds.	 1L 6"×6"×½"×0'-5½" Weight 9 Pounds,	B10
20	7.2	9/16			
21	5.8	19/32			B9
20	5.6	9/16			
21	4.4	19/32			B8
20	4.2	9/16			

The Maximum Reaction and the corresponding Least Span for safe uniform load are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web. Least spans for the above and other conditions are given on pages 136 to 139. For notes and tables relating to web strength, see pages 93 to 96.

The Least Web Thickness, t, of the supporting member between two equal beams framing opposite each other, is determined by the Maximum Reaction and the bearing on the field rivets.

MINIMUM SPANS, IN FEET, FOR WHICH DOUBLE CONNECTION ANGLES CAN BE USED ON

BETHLEHEM GIRDER BEAMS

CARRYING THEIR SAFE UNIFORMLY DISTRIBUTED LOADS.

Section Number.	Weight per Foot, Lbs.	LEAST SPAN, IN FEET, FOR VARIOUS CONDITIONS.								
		SHOP CONNECTION.		FIELD CONNECTION.						
		Rivet Stresses per Square Inch.		Rivet Stresses per Square Inch: Shearing 12,000 Lbs. Bearing 24,000 Lbs.						
		Shearing 13,500 Lbs. Bearing 27,000 Lbs.	Shearing 12,000 Lbs. Bearing 24,000 Lbs.	When two beams frame opposite each other to a beam or girder whose web thickness is as follows:						In any case where rivet shear governs.
				¼″	5⁄16″	⅜″	7⁄16″	½″	9⁄16″	
	200.0	19.1	21.5	50.6	40.5	33.8	28.9	25.3	22.5	21.5
G30	190.0	18.1	20.4	48.1	38.4	32.0	27.5	24.0	21.5	20.4
	181.0	17.8	19.4	45.6	36.5	30.4	26.1	22.8	20.3	19.4
G28	175.0	17.9	20.1	47.3	37.9	31.6	27.1	23.7	21.0	20.1
	165.0	16.9	19.0	44.8	35.8	29.8	25.6	22.4	19.9	19.0
	160.0	15.3	17.3	40.7	32.5	27.1	23.2	20.3	18.1	17.3
G26	151.0	15.9	16.3	38.4	30.7	25.6	21.9	19.2	17.1	16.3
	144.0	16.0	16.0	36.3	29.0	24.2	20.7	18.1	16.1	15.4
	149.0	15.5	17.4	41.0	32.8	27.3	23.4	20.5	18.2	17.4
G24a	141.0	14.9	16.4	38.7	30.9	25.8	22.1	19.3	17.2	16.4
	133.0	15.3	15.7	36.4	29.1	24.3	20.8	18.2	16.2	15.5
	129.0	14.8	15.3	35.4	28.3	23.6	20.2	17.7	15.7	15.0
G24	121.0	15.7	15.7	33.2	26.6	22.1	19.0	16.6	14.8	14.1
	114.0	16.3	16.3	31.1	24.9	20.7	17.8	15.5	13.8	13.2
	149.0	15.5	17.5	41.2	32.9	27.4	23.5	20.6	18.3	17.5
G20a	142.0	14.7	16.6	39.1	31.3	26.1	22.3	19.5	17.4	16.6
	135.0	14.0	15.7	37.0	29.6	24.7	21.2	18.5	16.5	15.7
	120.0	12.5	14.1	33.2	26.6	22.1	19.0	16.6	14.8	14.1
G20	113.0	12.4	13.9	31.2	25.0	20.8	17.8	15.6	13.9	13.2
	107.0	12.3	13.6	29.3	23.4	19.5	16.7	14.6	13.0	12.4
	100.0	11.8	12.2	25.4	20.3	16.9	14.5	12.7	11.3	10.8
G18	93.0	12.4	12.4	23.6	18.9	15.7	13.5	11.8	10.5	10.0
	87.5	12.4	12.4	22.0	17.6	14.6	12.5	11.0	9.8	9.3

The Least Spans given under the heading SHOP CONNECTION are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web.

The longest Least Span for any of the governing conditions is the minimum span for which the connection may be used.

For additional information on connection angles, see pages 125 and 127.

MINIMUM SPANS, IN FEET, FOR WHICH DOUBLE CONNECTION ANGLES CAN BE USED ON

BETHLEHEM GIRDER BEAMS

CARRYING THEIR SAFE UNIFORMLY DISTRIBUTED LOADS.

Section Number.	Weight per Foot, Lbs.	LEAST SPAN, IN FEET, FOR VARIOUS CONDITIONS.								
		SHOP CONNECTION.		FIELD CONNECTION.						
		Rivet Stresses per Square Inch.		Rivet Stresses per Square Inch: Shearing 12,000 Lbs. Bearing 24,000 Lbs.						
		Shearing 13,500 Lbs. Bearing 27,000 Lbs.	Shearing 12,000 Lbs. Bearing 24,000 Lbs.	When two beams frame opposite each other to a beam or girder whose web thickness is as follows:						In any case where rivet shear governs.
				¼″	5⁄16″	⅜″	7⁄16″	½″	9⁄16″	
G15b	Special connection angles to be used for G15b.									
G15a	111.0	10.9	12.2	28.8	23.0	19.2	16.5	14.4	12.8	12.2
	105.0	10.2	11.5	27.1	21.7	18.0	15.5	13.5	12.0	11.5
	99.0	9.9	11.1	25.4	20.3	16.9	14.5	12.7	11.3	10.8
G15	80.5	9.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.5	9.1
	74.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.3
	69.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.7
G12a	76.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.2
	70.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.5
	66.0	9.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.2	8.2	7.8
G12	61.0	9.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.8	7.8	7.5
	55.5	9.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.0	7.1	6.8
	51.5	9.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.4	6.6	6.3
G10	50.0	11.2	12.6	[illegible]	[illegible]	[illegible]	10.4	9.1	8.1	7.7
	44.5	11.3	12.7	[illegible]	[illegible]	[illegible]	9.3	8.2	7.2	6.9
	41.5	10.8	12.2	15.1	12.1	10.0	8.6	7.5	6.7	6.4
G9	43.5	9.0	10.1	14.2	11.3	9.4	8.1	7.1	6.3	6.0
	38.5	9.1	10.2	12.6	10.1	8.4	7.2	6.3	5.6	5.4
	36.0	9.1	10.2	11.8	9.5	7.9	6.8	5.9	5.3	5.0
G8	37.0	7.3	8.2	10.8	8.6	7.2	6.2	5.4	4.8	4.6
	33.0	7.1	7.9	9.5	7.6	6.4	5.4	4.8	4.2	4.0
	31.0	6.8	7.7	8.9	7.1	5.9	5.1	4.5	4.0	3.8

The Least Spans given under the heading SHOP CONNECTION are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web.

The longest Least Span for any of the governing conditions is the minimum span for which the connection may be used.

For additional information on connection angles, see page 129.

MINIMUM SPANS, IN FEET, FOR WHICH DOUBLE CONNECTION ANGLES CAN BE USED ON

BETHLEHEM I BEAMS

CARRYING THEIR SAFE UNIFORMLY DISTRIBUTED LOADS.

Section Number.	Weight per Foot, Lbs.	LEAST SPAN, IN FEET, FOR VARIOUS CONDITIONS.								
		SHOP CONNECTION.		FIELD CONNECTION.						
		Rivet Stresses per Square Inch.		Rivet Stresses per Square Inch: Shearing 12,000 Lbs. Bearing 24,000 Lbs.						
		Shearing 13,500 Lbs. Bearing 27,000 Lbs.	Shearing 12,000 Lbs. Bearing 24,000 Lbs.	When two beams frame opposite each other to a beam or girder whose web thickness is as follows:						In any case where rivet shear governs.
				¼″	5/16″	3/8″	7/16″	½″	9/16″	
B30	129.0	21.0	23.6	54.8	43.8	36.5	31.3	27.4	24.3	23.2
	121.0	20.8	23.4	51.5	41.2	34.3	29.4	25.7	22.9	21.9
	115.0	20.3	22.9	48.5	38.8	32.3	27.7	24.2	21.5	20.6
B28	113.0	20.9	23.5	50.8	40.6	33.9	29.0	25.4	22.6	21.6
	106.0	20.7	23.3	47.6	38.0	31.7	27.2	23.8	21.1	20.2
	100.0	20.2	22.7	44.5	35.6	29.7	25.4	22.3	19.8	18.9
B26	98.0	20.7	23.3	46.7	37.3	31.1	26.7	23.3	20.7	19.8
	91.0	20.5	23.1	43.4	34.7	28.9	24.8	21.7	19.3	18.4
	85.5	19.9	22.4	40.4	32.3	26.9	23.1	20.2	17.9	17.1
B24b	104.5	19.0	21.3	46.9	37.5	31.3	26.8	23.5	20.9	19.9
	99.5	18.9	21.3	44.6	35.7	29.8	25.5	22.3	19.8	18.9
	95.5	18.7	21.0	42.4	34.0	28.3	24.3	21.2	18.9	18.0
B24a	84.5	18.2	20.5	37.8	30.2	25.2	21.6	18.9	16.8	16.0
B24	79.5	18.3	20.6	35.5	28.4	23.7	20.3	17.8	15.8	15.1
	73.5	18.6	21.0	33.1	26.5	22.1	18.9	16.6	14.7	14.1
B22	71.5	18.1	20.4	34.3	27.4	22.8	19.6	17.1	15.2	14.5
	68.5	18.0	20.3	32.8	26.3	21.9	18.8	16.4	14.6	13.9
	65.5	18.1	20.3	31.3	25.0	20.9	17.9	15.7	13.9	13.3
B20a	78.0	20.1	22.6	41.6	33.3	27.8	23.8	20.8	18.5	17.7
	73.0	20.2	22.8	39.1	31.3	26.1	22.4	19.6	17.4	16.6
B20	64.5	18.9	21.3	34.0	27.2	22.7	19.4	17.0	15.1	14.4
	62.0	18.6	20.9	32.6	26.1	21.8	18.7	16.3	14.5	13.9
	59.5	18.5	20.8	31.2	25.0	20.8	17.8	15.6	13.9	13.2

The Least Spans given under the heading SHOP CONNECTION are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web.

The longest Least Span for any of the governing conditions is the minimum span for which the connection may be used.

For additional information on connection angles, see pages 125 and 127.

MINIMUM SPANS, IN FEET, FOR WHICH DOUBLE CONNECTION ANGLES CAN BE USED ON

BETHLEHEM I BEAMS

CARRYING THEIR SAFE UNIFORMLY DISTRIBUTED LOADS.

Section Number.	Weight per Foot, Lbs.	LEAST SPAN, IN FEET, FOR VARIOUS CONDITIONS.								
		SHOP CONNECTION.		FIELD CONNECTION.						
		Rivet Stresses per Square Inch.		Rivet Stresses per Square Inch: Shearing 12,000 Lbs. Bearing 24,000 Lbs.						
		Shearing 13,500 Lbs. Bearing 27,000 Lbs.	Shearing 12,000 Lbs. Bearing 24,000 Lbs.	When two beams frame opposite each other to a beam or girder whose web thickness is as follows:						In any case where rivet shear governs.
				¼"	5/16"	⅜"	7/16"	½"	9/16"	
B18a	74.0	18.4	20.7	36.4	29.1	24.3	20.8	18.2	16.2	15.5
	69.0	17.9	20.1	33.8	27.1	22.6	19.3	16.9	15.0	14.4
	64.5	17.4	19.6	31.3	25.0	20.9	17.9	15.6	13.9	13.3
B18	54.5	15.7	17.7	26.2	20.9	17.4	14.9	13.1	11.6	11.1
	52.0	15.6	17.6	24.9	19.9	16.6	14.2	12.5	11.1	10.6
	49.0	15.9	17.9	23.6	18.9	15.7	13.5	11.8	10.5	10.0
B15b	71.5	10.0	11.3	35.1	28.1	23.4	20.1	17.6	15.6	14.9
B15a	59.5	9.7	10.9	29.5	23.6	19.6	16.8	14.7	13.1	12.5
	54.5	9.8	11.0	27.1	21.7	18.1	15.5	13.6	12.0	11.5
	50.5	9.6	10.8	24.9	19.9	16.6	14.2	12.5	11.1	10.6
B15	42.5	9.8	11.0	21.5	17.2	14.3	12.3	10.8	9.6	9.1
	40.0	9.9	11.1	20.3	16.3	13.6	11.6	10.2	9.0	8.6
	38.5	10.5	11.3	19.7	15.7	13.1	11.2	9.8	8.7	8.3
B12a	36.5	7.5	8.0	20.0	16.0	13.3	11.4	10.0	8.9	8.5
B12	31.0	8.1	8.1	17.1	13.7	11.4	9.8	8.6	7.6	7.3
	28.5	8.7	8.7	16.0	12.8	10.7	9.1	8.0	7.1	6.8
B10	26.0	7.4	8.4	18.1	14.5	12.0	10.3	9.0	8.0	7.7
	23.5	7.2	8.1	16.3	13.0	10.8	9.3	8.1	7.2	6.9
B9	22.0	5.8	6.6	13.7	10.9	9.1	7.8	6.8	6.1	5.8
	20.5	5.6	6.3	12.7	10.1	8.4	7.2	6.3	5.6	5.4
B8	19.0	4.3	4.8	10.4	8.3	6.9	5.9	5.2	4.6	4.4
	17.5	4.2	4.7	9.5	7.6	6.3	5.4	4.7	4.2	4.0

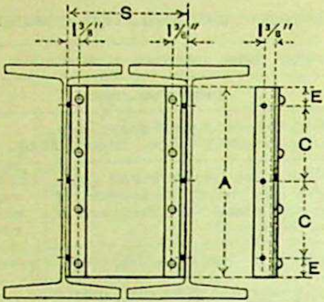
The Least Spans given under the heading SHOP CONNECTION are determined by the shearing and bearing values of the rivets in the connection angles and the strength of the beam web.

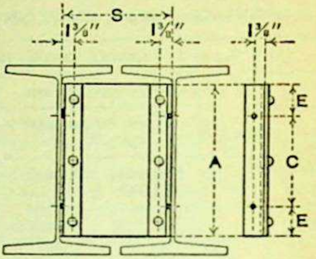
The longest Least Span for any of the governing conditions is the minimum span for which the connection may be used.

For additional information on connection angles, see pages 133 and 135.

BUILT-UP SEPARATORS FOR

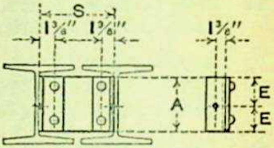
BETHLEHEM GIRDER BEAMS.





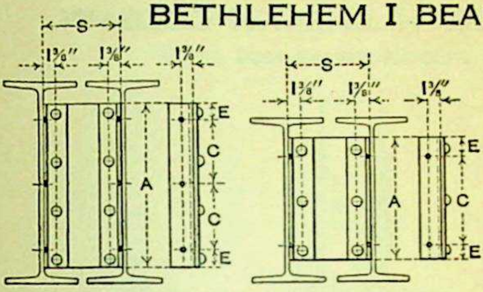
Angles: 2½" x 2½" x 5/16".
Plates: 5/16" Thick.

Rivets: ¾" Diameter.
Bolts: ¾" Diameter.
Holes: 13/16" Diameter.

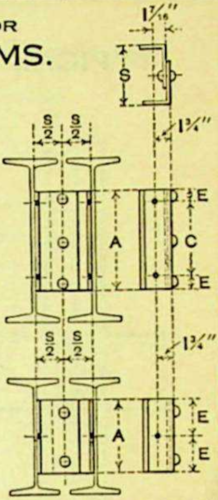


GIRDER BEAMS.			DISTANCES.		SEPARATORS.					BOLTS.	
Section Number.	Nominal Depth, Inches.	Weight per Foot, Pounds.	Out to Out of Flanges, Inches.	Center to Center Beams, Inches.	DIMENSIONS, IN INCHES.				Weight, in Pounds.	Length under Head, Inches.	Weight, in Pounds.
					S	A	C	E			
SEPARATORS WITH THREE BOLTS.											
G30	30	190.0	30¾	15¾	15	25	9	3½	56.2	17½	7.8
G28	28	165.0	29 3/16	14 15/16	14¼	23	9	2½	50.1	16¾	7.6
G26	26	151.0	28⅜	14⅝	14	21	9	1½	45.8	16¼	7.0
SEPARATORS WITH TWO BOLTS.											
G24a	24	141.0	27⅜	14⅛	13½	20	12	4	42.4	15¾	4.8
G24	24	121.0	25¼	13	12½	20	12	4	40.6	14½	4.5
G20a	20	142.0	26 3/16	13 7/16	12¾	15½	12	1¾	31.7	15	4.6
G20	20	113.0	24 13/16	12 13/16	12¼	15½	12	1¾	31.1	14¼	4.4
G18	18	93.0	23½	12	11½	14	9	2½	27.7	13½	4.2
G15b	15	141.0	24 1/16	12 5/16	11½	10	6	2	20.2	14	4.3
G15a	15	105.0	23⅛	11⅞	11¼	11	6	2½	21.7	13½	4.2
G15	15	74.0	21 15/16	11 3/16	10¾	12	6	3	22.9	12¾	4.0
G12a	12	70.5	21	10¾	10¼	9	6	1½	17.2	12¼	3.9
G12	12	55.5	20⅝	10⅝	10¼	9	6	1½	17.2	12	3.8
SEPARATORS WITH ONE BOLT.											
G10	10	44.5	18 9/16	9 9/16	9¼	7½	....	3¾	13.3	10¾	1.8
G 9	9	38.5	17 9/16	9 1/16	8¾	6½	....	3¼	11.4	10¼	1.7
G 8	8	33.0	16 9/16	8 9/16	8¼	6	....	3	10.4	9¾	1.7

BUILT-UP SEPARATORS FOR
BETHLEHEM I BEAMS.



TYPE NO. 1.



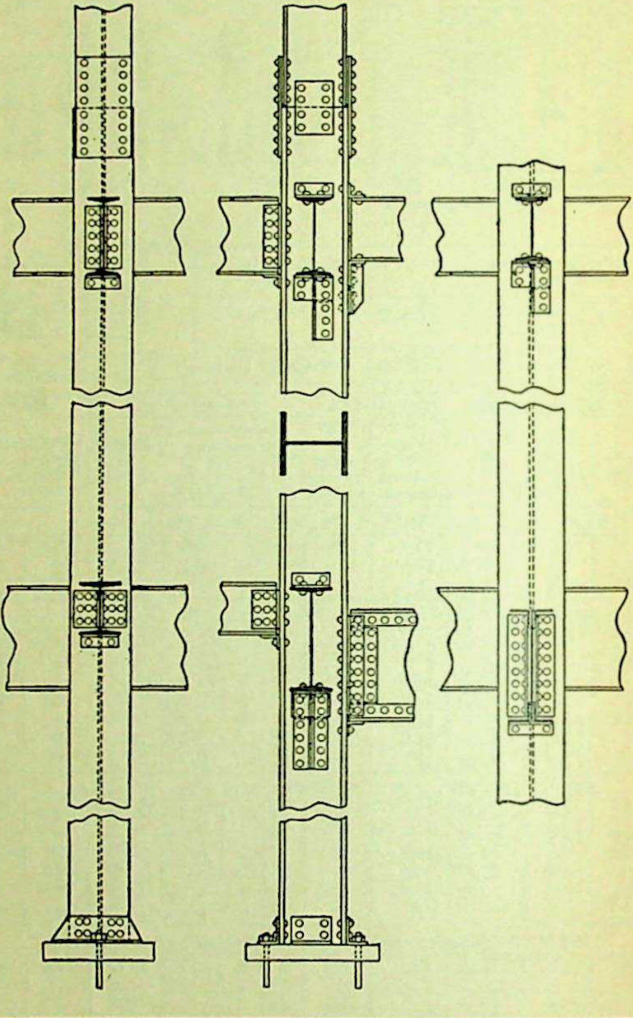
TYPE NO. 2.

MATERIAL FOR TYPE NO. 1.	MATERIAL FOR TYPE NO. 2.
Angles: 2½" x 2½" x 5/16". Plates: 5/16" Thick.	Angles: 5" x 3" x 5/16".
Rivets: ¾" Diam.; Bolts: ¾" Diam.; Holes: 13/16" Diam.	

BETHLEHEM BEAMS.			DISTANCES.		SEPARATORS.					BOLTS.	
Section Number.	Nominal Depth, Inches.	Weight per Foot, Pounds.	Out to Out of Flanges, Inches.	Center to Center Beams, Inches.	DIMENSIONS, IN INCHES. S	A	C	E	Weight, in Pounds.	Length under Head, Inches.	Weight, in Pounds.
SEPARATORS WITH THREE BOLTS. TYPE NO. 1.											
B30	30	121.0	21 9/16	11 1/16	10½	26	9	4	48.2	12½	6.0
B28	28	106.0	20½	10½	10	24	9	3	43.5	12	5.8
B26	26	91.0	19½	10	9½	22	9	2	39.0	11½	5.6
SEPARATORS WITH TWO BOLTS. TYPE NO. 1.											
B24b	24	99.5	20 1/16	10 5/16	9¾	20	12	4	35.3	11¾	3.8
B24a	24	84.5	19¼	9¼	9¼	20	12	4	34.4	11¼	3.6
B24	24	73.5	18⅝	9⅝	9¼	20	12	4	34.4	11	3.6
B22	22	65.5	17⅝	9⅛	8¾	19	12	3½	31.8	10½	3.5
B20a	20	73.0	18 9/16	9 7/16	9	17	12	2½	29.5	11	3.6
B20	20	59.5	16⅝	8⅝	8¼	17	12	2½	28.0	10	3.3
B18a	18	69.0	18 7/16	9 5/16	9	15	9	3	26.2	10¾	3.5
SEPARATORS WITH TWO BOLTS. TYPE NO. 2.											
B18	18	49.0	15 5/16	8 1/16	7¾	15	9	3	22.0	9¼	3.2
B15b	15	71.5	15½	8	7½	11	6	2½	16.5	9½	3.2
B15a	15	54.5	14 7/16	7 7/16	7	12	6	3	17.9	9	3.1
B15	15	38.5	14 1/16	7 5/16	7	12	6	3	17.9	8½	3.0
B12a	12	36.5	13 3/16	6 13/16	6½	9½	6	1¾	14.5	8¼	2.9
B12	12	28.5	13	6¾	6½	9½	6	1¾	14.5	8	2.8
SEPARATORS WITH ONE BOLT. TYPE NO. 2.											
B10	10	23.5	12	6¼	6	8	....	4	11.9	7½	1.4
B 9	9	20.5	11½	6	5¾	7	....	3½	10.6	7¼	1.3
B 8	8	17.5	11	5¾	5½	6	....	3	9.2	7	1.3

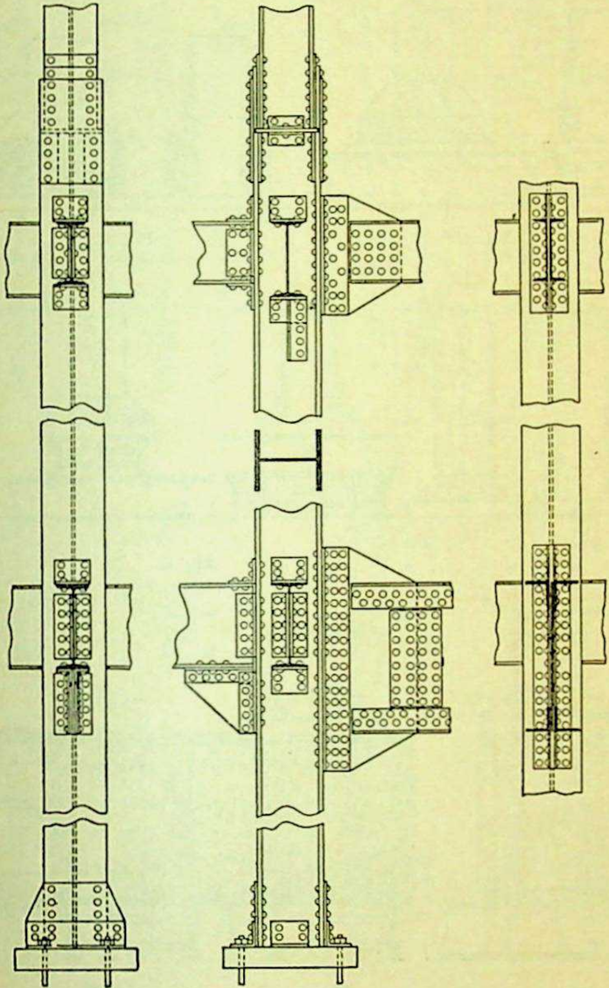
TYPICAL BETHLEHEM H COLUMN.

FLOOR FRAMING.



TYPICAL BETHLEHEM H COLUMN.

WIND BRACING CONNECTIONS.



TYPICAL COLUMN BASES.

SLABS AND GRILLAGES.

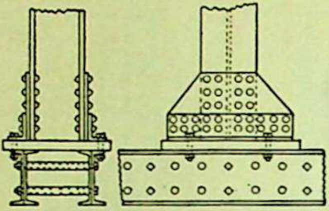


Fig. 1.

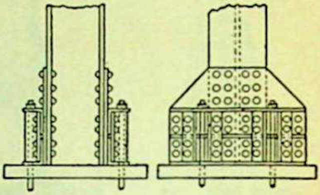


Fig. 2.

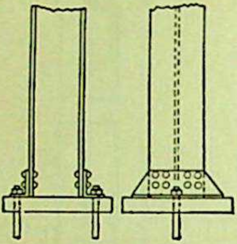


Fig. 3.

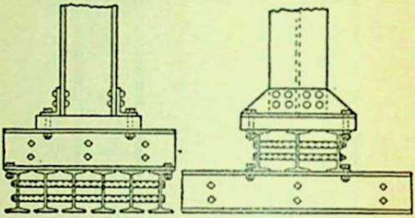


Fig. 4.

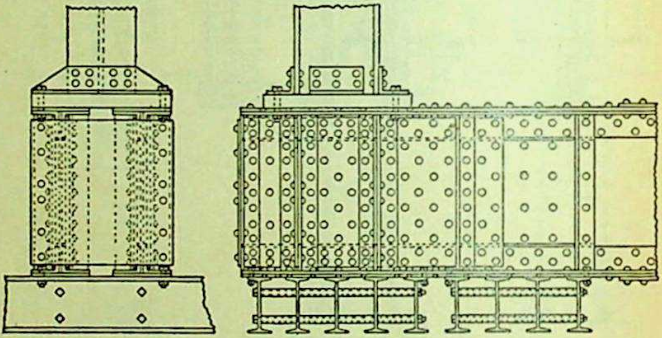


Fig. 5.

TYPICAL SPANDREL FRAMING.

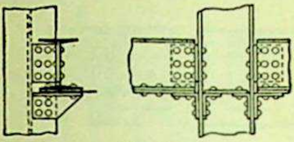


Fig. 1.

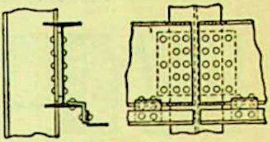


Fig. 2.

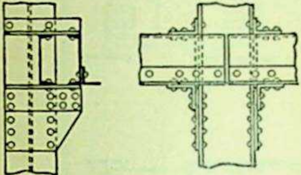


Fig. 3.

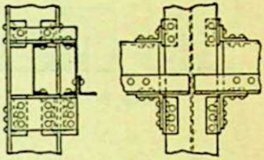


Fig. 4.

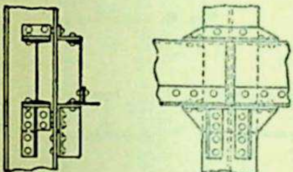


Fig. 5.

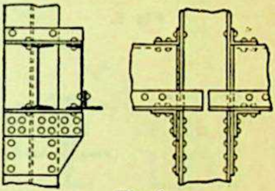


Fig. 6.

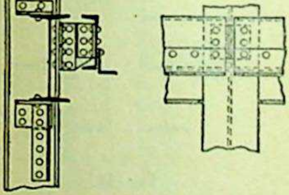


Fig. 7.

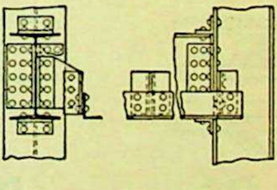


Fig. 8.

TYPICAL CONNECTIONS FOR BEAMS FRAMING TO BEAMS.

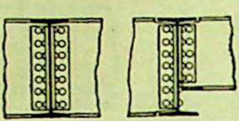


Fig. 1.

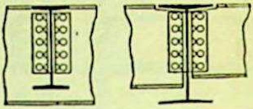


Fig. 2.

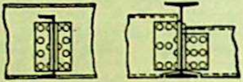


Fig. 3.

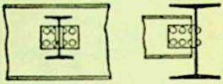


Fig. 4.

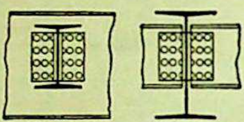


Fig. 5.

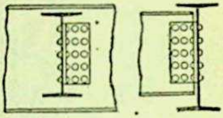


Fig. 6.

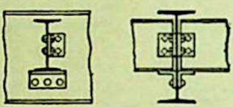


Fig. 7.

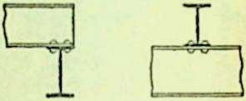


Fig. 8.

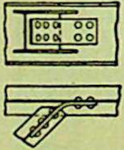


Fig. 9.

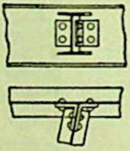


Fig. 10.

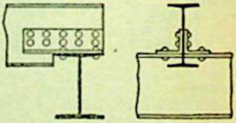


Fig. 11.

TYPICAL MILL BUILDING CONSTRUCTION.

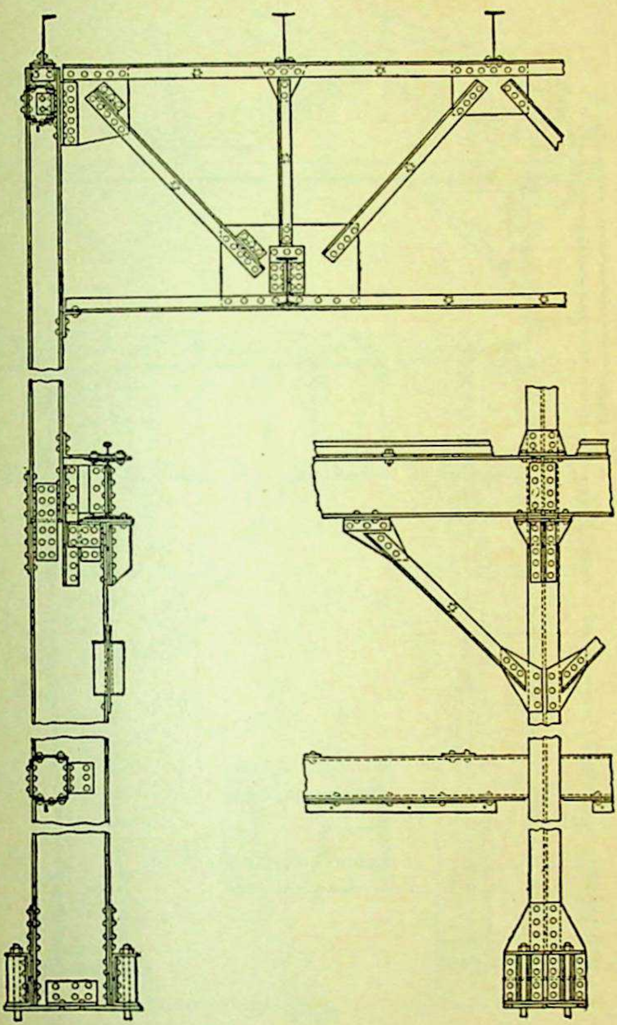


Fig. 1.

TYPICAL MILL BUILDING CONSTRUCTION.

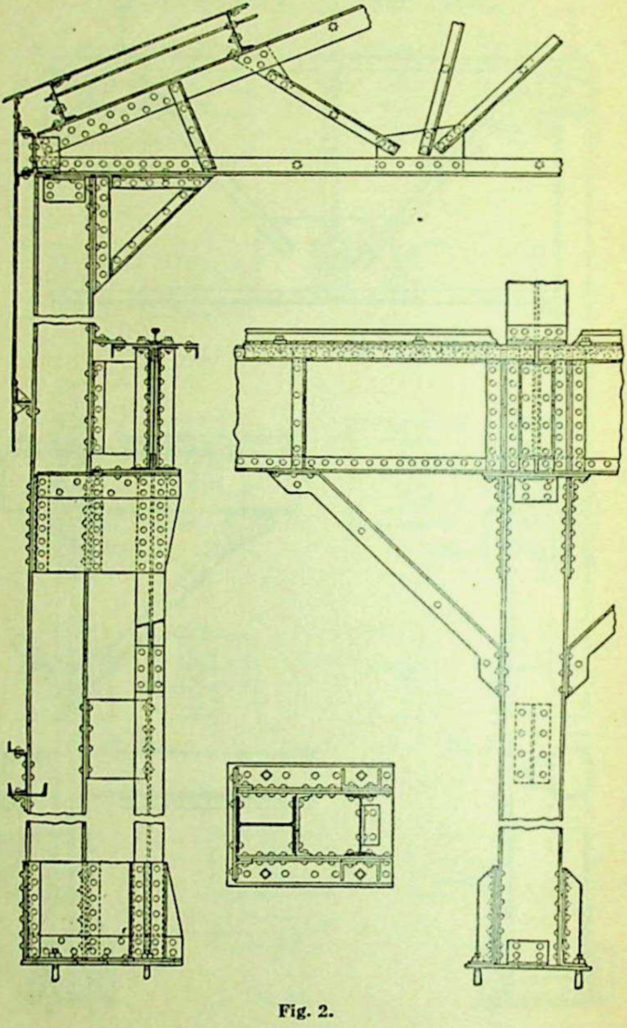


Fig. 2.

TYPICAL MILL BUILDING CONSTRUCTION.

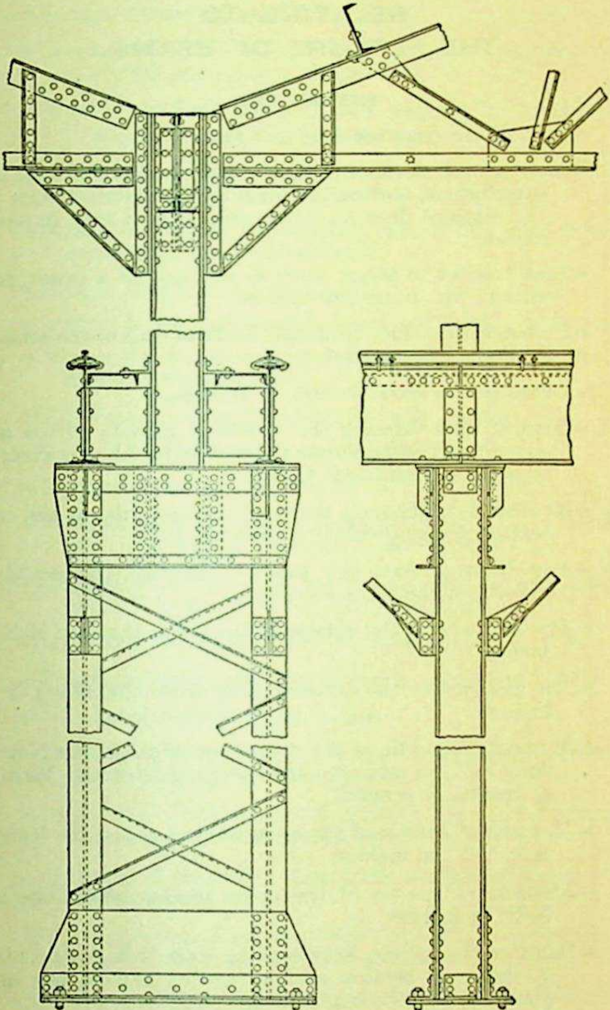


Fig. 3.

FORMULAS RELATING TO THE FLEXURE OF BEAMS.

NOTATION.

A = Area of the cross section, in square inches.

A_1 = Area of the portion of the cross section between any longitudinal section parallel to the Neutral Axis and the extreme fiber on either side of that axis, in square inches.

A_2 = Area subject to shear, such as the web of a beam, plate girder, etc., in square inches.

c = Distance, in inches, from the Neutral Axis to the center of gravity of the area A_1.

D = Depth of the cross section, in inches.

X-X = Neutral Axis through the center of gravity of the cross section perpendicular to the web of an I beam, channel, or other symmetrical section.

Y-Y = Neutral Axis through the center of gravity of the cross section perpendicular to the axis X-X.

N-N = Any Neutral Axis not passing through the center of gravity of the cross section.

n = The distance to the extreme fiber from the axis X-X, in inches.

n' = The distance to the extreme fiber from the axis Y-Y, in inches.

I = Moment of Inertia of the cross section about the Neutral Axis X-X, in inches^4. It is also used for any Moment of Inertia in general.

I' = Moment of Inertia of the cross section about the Neutral Axis Y-Y, in inches^4.

I'' = Moment of Inertia of the cross section about the axis N-N, in inches^4.

z = Distance, in inches, between the axis N-N in the plane of the cross section and a parallel axis in the same plane through its center of gravity.

r = Radius of Gyration, axis X-X, in inches.

r' = Radius of Gyration, axis Y-Y, in inches.

S = Section Modulus, axis X-X, inches^3.

S' = Section Modulus, axis Y-Y, inches^3.

C = Coefficient of Strength, in foot pounds, for a unit stress of 18,000 pounds per square inch.

C' = Coefficient of Strength, in foot pounds, for a unit stress of 16,000 pounds per square inch.

C'' = Coefficient of Strength, in foot pounds, for a unit stress of 12,000 pounds per square inch.

f = Stress, in pounds per square inch, in the fiber most remote from the Neutral Axis.

L = Length of span, in feet.

l = Length of span of beam or length of column, in inches.

R = Moment of Resistance of the cross section, in inch pounds unless otherwise noted.

M = External Bending Moment, in inch pounds.

M_f = External Bending Moment, in foot pounds.

V = Vertical shear on the cross section, in pounds.

v = Vertical or longitudinal shearing stress at any point of the cross section, in pounds per square inch.

t = Thickness of the cross section in any plane cutting it parallel to the Neutral Axis, in inches.

P = Load concentrated at any point of the beam, in pounds.

W = Total uniformly distributed load, in pounds.

d = Maximum deflection, in inches.

H = Deflection Coefficient, in inches^2, for a unit stress of 18,000 pounds per square inch.

H' = Deflection Coefficient, in inches^2, for a unit stress of 16,000 pounds per square inch.

E = Modulus of elasticity, in pounds per square inch;
= 29,000,000 for steel.

f'' = The maximum instantaneous fiber stress, in pounds per square inch, due to a falling load.

d'' = The maximum deflection, in inches, due to a falling load.

h = Height of fall of the load, in inches.

GENERAL FORMULAS.

Bending Moments, safe loads, shears, deflections, etc., for certain types of sections and conditions of loading are given, together with other data, on pages 166 to 169. Diagrams are also given on these pages to make the subject more clear. The following formulas include some of those given with the diagrams and also others for different conditions in order to make this matter more complete.

$$I'' = Az^2 + I \qquad r = \sqrt{\frac{I}{A}} \qquad S = \frac{I}{n} = \frac{Ar^2}{n}$$

$$M = R = \frac{fI}{n} = fS$$

$$f = \frac{Mn}{I} = \frac{M}{S} \qquad r' = \sqrt{\frac{I'}{A}} \qquad S' = \frac{I'}{n'} = \frac{Ar'^2}{n'}$$

For sections symmetrical about the Neutral Axis, the formulas for M and f may take the form:—

$$M = \frac{2fI}{D} \qquad f = \frac{MD}{2I}$$

Coefficient of Strength.

$$C = \frac{2fI}{3n} = \frac{2fS}{3}$$

$C = 12{,}000\ S$, if $f = 18{,}000$ pounds per square inch.
$C' = 10{,}667\ S$, if $f = 16{,}000$ pounds per square inch.
$C'' = 8{,}000\ S$, if $f = 12{,}000$ pounds per square inch.

Coefficient of Deflection.

$$H = \frac{30fL^2}{E}$$

$H = .01862\ L^2$, if $f = 18{,}000$ pounds per square inch.
$H' = .01655\ L^2$, if $f = 16{,}000$ pounds per square inch.

SAFE LOADS.

Bending.

1. Beam supported at the ends and loaded uniformly.

$$M=\frac{Wl}{8}=\frac{3WL}{2} \qquad W=\frac{8M}{l}=\frac{8fS}{l}=\frac{C}{L}$$

2. Beam supported at the ends with a single load concentrated at the center.

$$M=\frac{Pl}{4}=3PL \qquad P=\frac{4M}{l}=\frac{4fS}{l}=\frac{C}{2L}$$

3. Beam fixed at one end, free at the other, load uniformly distributed.

$$M=\frac{Wl}{2}=6WL \qquad W=\frac{2M}{l}=\frac{2fS}{l}=\frac{C}{4L}$$

4. Beam fixed at one end, free at the other, with a single load concentrated at the free end.

$$M=Pl=12PL \qquad P=\frac{M}{l}=\frac{fS}{l}=\frac{C}{8L}$$

5. Beam fixed at both ends, load uniformly distributed. The maximum Bending Moments occur at the points of support of the beam and are equal.

$$M=\frac{Wl}{12}=WL \qquad W=\frac{12M}{l}=\frac{12fS}{l}=\frac{3C}{2L}$$

6. Beam fixed at both ends with a single load concentrated at the center. The maximum Bending Moments occur at the center and points of support of the beam, are equal, and opposite in direction.

$$M=\frac{Pl}{8}=\frac{3PL}{2} \qquad P=\frac{8M}{l}=\frac{8fS}{l}=\frac{C}{L}$$

Shear.

$$V=12{,}000A_2$$

In which A_2 is the area subject to shear, such as the web of a beam or plate girder.

Buckling of Webs. See notes on pages 93 and 94.

Lateral Support. See notes on pages 74 and 75.

MAXIMUM DEFLECTIONS.

1. Beam supported at the ends and loaded uniformly.

$$d=\frac{5}{384}\ \frac{Wl^3}{EI}=22.5\ \frac{WL^3}{EI}$$

$$d=15\ \frac{fL^2}{En} \qquad \text{also, } d=\frac{H}{2n}$$

If the beam cross section is symmetrical about the Neutral Axis, the last formula may be simplified to, $d=\frac{H}{D}$

2. Beam supported at the ends with a single load concentrated at the center.

$$d=\frac{Pl^3}{48EI}=12\ \frac{fL^2}{En}=.80\ \frac{H}{2n}$$

For symmetrical sections, $d=.80\ \frac{H}{D}$

3. Beam fixed at one end, free at the other, load uniformly distributed.

$$d=\frac{Wl^3}{8EI}=36\ \frac{fL^2}{En}=2.40\ \frac{H}{2n}$$

For symmetrical sections, $d=2.40\ \frac{H}{D}$

4. Beam fixed at one end, free at the other, with a single load concentrated at the free end.

$$d=\frac{Pl^3}{3EI}=48\ \frac{fL^2}{En}=3.20\ \frac{H}{2n}$$

For symmetrical sections, $d=3.20\ \frac{H}{D}$

5. Beam fixed at both ends, load uniformly distributed.

$$d=\frac{Wl^3}{384EI}=4.50\ \frac{fL^2}{En}=.30\ \frac{H}{2n}$$

For symmetrical sections, $d=.30\ \frac{H}{D}$

6. Beam fixed at both ends, with a single load concentrated at the center.

$$d=\frac{Pl^3}{192EI}=6\ \frac{fL^2}{En}=.40\ \frac{H}{2n}$$

For symmetrical sections, $d=.40\ \frac{H}{D}$

SHEAR.

$\frac{VA_1c}{I}$ = Shear per unit length of beam on any longitudinal section dividing the cross section into two parts, one of which is the area A_1.

$v = \frac{VA_1c}{It}$ = Average shearing stress on a longitudinal plane parallel to the Neutral Axis and dividing the cross section into two parts, one of which is the area A_1.

$v = \frac{V}{Dt}$ = Average intensity of shear in the gross area of the web.

$v = \frac{3V}{2A}$ = Intensity of shear at the Neutral Axis of a rectangle.

For the distribution of shear along the beam, see the diagrams on pages 166–168.

The maximum vertical shear for several types of loading is given by the formulas below.

1. Beam supported at the ends and loaded uniformly.

$$V = \frac{W}{2} = \frac{C}{2L}$$

2. Beam supported at the ends, with a single load concentrated at the center.

$$V = \frac{P}{2} = \frac{C}{4L}$$

3. Beam fixed at one end, free at the other, load uniformly distributed.

$$V = W = \frac{C}{4L}$$

4. Beam fixed at one end, free at the other, with a single load concentrated at the free end.

$$V = P = \frac{C}{8L}$$

5. Beam fixed at both ends, load uniformly distributed.

$$V = \frac{W}{2} = \frac{3C}{4L}$$

6. Beam fixed at both ends, with a single load concentrated at the center.

$$V = \frac{P}{2} = \frac{C}{2L}$$

IMPACT.

Fiber Stress and Deflection Due to Impact. See page 163.

EXPLANATORY NOTES RELATING TO THE FLEXURE OF BEAMS.

These notes will explain in a somewhat brief manner that part of the theory of flexure of beams which relates to rolled steel beams and girders of uniform cross section.

Information and data regarding the Properties, Safe Loads, Strengths and Deflections of beams are given in various tables throughout this book and, on preceding pages, formulas relating thereto are presented together for ease of reference. In order that the derivation and use of these formulas may be better understood, they are discussed in the following notes:—

Ordinary Theory of Flexure. In order to permit calculations to be made of the strength, deflection, and other data, for a beam subject to flexure, certain assumptions must be adopted as the basis for an approximate theory. The principal assumptions are as follows:—

1. All sections which are plane before bending remain plane after bending.
2. Each fiber of the beam is assumed free to extend or contract independently of every other fiber.
3. All stresses are assumed as proportional to the corresponding strains. The beam must be homogeneous so that the ratio of stress to strain, that is the modulus of elasticity, is constant over the whole cross section. The theory applies only when the material is not stressed beyond its elastic limit.

PROPERTIES OF SECTIONS.

Moment of Inertia. The Moment of Inertia of the cross section of a beam or other member is related to the stiffness and strength of the member and is the basis from which other properties of the beam are derived.

The Moment of Inertia for a beam in flexure is calculated from the area of its cross section. It is the sum of the products of all the infinitesimal or elementary areas of the cross section by the squares of their respective distances from the Neutral Axis.

As all the linear dimensions are usually stated in inches, the Moment of Inertia is expressed in inches to the fourth power.

For rolled structural steel sections, such as beams, girders, etc., I is the Moment of Inertia about a Neutral Axis X-X passing through the center of gravity parallel to the flanges and perpendicular to the web; I′ is the Moment of Inertia about a Neutral Axis Y-Y passing through the center of gravity and through the center of the web, this axis being perpendicular to the axis X-X; and I″ is the Moment of Inertia about an axis N-N parallel to any axis passing through the center of gravity.

The Moment of Inertia I″ about an axis N-N in the plane of the cross section parallel to any axis through the center of gravity is

$$I'' = Az^2 + I$$

in which z is the distance between the parallel axes.

Neutral Axis. The Neutral Axis of a cross section of a homogeneous beam, in accordance with the ordinary theory of flexure, is a straight line in the plane of the cross section passing through its center of gravity. At such a Neutral Axis, the tensile and compressive stresses in the beam, due to flexure alone, are zero while compression exists in the material on one side of the axis and tension on the other side.

Generally speaking, a Neutral Axis may have any direction, dependent on the direction of the forces acting on the beam. Ordinarily there are two such axes perpendicular to each other about which the section will offer the greatest and least resistance to flexure. These axes are called the principal axes; are mutually perpendicular to each other; and, for symmetrical sections, at least one of them coincides with an axis of symmetry. In an I beam, for instance, resistance to flexure is greatest about the gravity axis perpendicular to the web and is smallest about the gravity axis parallel to, and through the center of the web. These lines are often called the major and minor Neutral Axes of the beam.

Section Modulus. The Section Modulus is a function of the area of the cross section of a beam or other member about either axis X-X or Y-Y and is derived from the Moment of Inertia by dividing it by the normal distance, in inches, from the Neutral

Axis to that portion of the section most remote from that axis. This results in an expression for the Section Modulus, in inches cubed, since the Moment of Inertia is in inches to the fourth power.

The strength of a beam in flexure depends on the strength of its weakest part, and as that portion of the beam section most remote from the Neutral Axis is subjected to the highest stress in bending, it is the allowable stress in such portion which governs its use in these respects. The customary maximum allowable stress for steel beams in flexure, as stated in the tables herein, is 18,000 pounds per square inch in the fibers most remote from the Neutral Axis.

The Section Modulus, S, is

$$S = \frac{I}{n}$$

in which I is the Moment of Inertia about the principal axis normal to the plane of loading, and n is the distance to the extreme fiber from the Neutral Axis.

Radius of Gyration. The Radius of Gyration, r, is

$$r = \sqrt{\frac{I}{A}}$$

The Radius of Gyration is an indicator of the value of a member when used as a column; the greater the Radius of Gyration for the chosen form of section composed of one or more structural shapes, or for a given weight of such forms, the greater the unit stress allowable on the member when used as a column.

The allowable unit stress in a column depends upon the ratio of $\frac{l}{r}$, where r is the least Radius of Gyration of the column, or portion thereof under consideration, and l, the length, both in inches. The formula given below for this stress is applicable to primary members when the ratio $\frac{l}{r}$ lies between the limits of 60 and 120; also to larger ratios which may be used for secondary members. When the ratio exceeds 60, the following formula is used to determine the allowable unit stress:—

$$f = \frac{18{,}000}{1 + \frac{l^2}{18{,}000 r^2}}$$

in which f is the allowable fiber stress in the column cross section. For a more complete discussion of the strength of columns, see the notes relating thereto on pages 97 to 100.

Moment of Resistance. The Moment of Resistance, R, of a beam is a function of its cross section indicating the strength of the beam in flexure. It is dependent on the Section Modulus, S, of the cross section and the maximum allowable unit stress in the extreme fibers.

The Moment of Resistance is obtained by multiplying the Section Modulus by the allowable stress, in pounds per square inch, in the extreme fibers and is expressed by the following formula:—

$$R = \frac{I}{n} f = fS$$

In designing beams, this Moment of Resistance should equal the total Bending Moment of the loads and reactions, or external forces, at the section in question. This is expressed by:—

$$R = M = 12M_f$$

Coefficient of Strength. The Coefficient of Strength is the safe uniformly distributed load on a beam 1 foot long when the Bending Moment produces the allowable unit stress in the extreme fibers.

The safe uniformly distributed load on a beam is inversely proportional to the span for any given unit stress in the extreme fiber. Hence the safe uniform load, in pounds, on any given span is equal to the Coefficient of Strength for the given beam divided by its span in feet, namely:—

$$W = \frac{C}{L}, \quad \text{or} \quad C = WL$$

The Coefficient of Strength is dependent on the allowable unit stress in the extreme fibers and the Section Modulus. It is expressed by the following formula:—

$$C = \frac{2fI}{3n} = \frac{2}{3} fS$$

The Coefficient of Strength may also be equated to the external moment of the loading as follows:—

$$C, C', \text{or } C'' = 8M_f = \frac{2}{3} M$$

Three Coefficients of Strength, namely C, C′, and C″, are given in the tables, corresponding respectively to stresses in the extreme fibers of 18,000, 16,000, and 12,000 pounds per square inch.

BENDING MOMENT.

The Bending Moment at any cross section of a simple beam is equal to the algebraic sum of all the moments acting on the beam between the given cross section and one end, whether the moments are due to loads or reactions. The loads and reactions may be considered as having opposite signs, plus or minus. The Bending Moments on the two sides of a cross section are equal in magnitude so that the moment at the section may be figured from the algebraic sum of the moments of the reactions and loads most easily calculated.

The greatest Bending Moment in a simple beam occurs at the section where the shear changes from positive to negative. If the concentrated loads are large, compared with the distributed loads, the maximum moment will occur under one of them. The relations between the Bending Moments, the Section Modulus, and the maximum fiber stresses in a beam subject to flexure are as follows:—

$$S=\frac{M}{f}=\frac{12M_f}{f} \quad \text{and} \quad f=\frac{M}{S}=\frac{12M_f}{S}$$

In the above equations, f is the stress in the extreme fiber of the cross section due to the total Bending Moment acting upon it.

Stresses due to loads or forces acting in directions different from the customary gravity loads must be figured separately and compounded with the stresses due to the total moment of the gravity loads.

The required Moment of Resistance is found as follows:—

$$R=M=12M_f$$

The relation of the Coefficient of Strength, C, to the Bending Moments is as follows:—

$$C=8M_f=\frac{2}{3}M$$

SHEAR AND SHEARING STRESSES.

The vertical shear at any section of a simple beam equals either reaction added algebraically to the external loads acting on the same side of the cross section as the reaction considered. The maximum vertical shear in a simple beam occurs near, and is generally equal to, the greater of the two reactions.

The total shear is a maximum at the points of support for uniform loading, and uniform throughout from the point of loading to the supports for a superimposed concentrated load at the center.

The vertical shears for different systems of loading may be obtained by the use of moments in the usual way, and these are given for various cases on pages 166 to 169, inclusive.

The longitudinal shear per inch of beam length on any section parallel to the Neutral Axis is equal to $\frac{VA_1c}{I}$.

The shearing stresses in beams vary from zero at the extreme fibers to a maximum in the plane of the Neutral Axes.

The average intensity of the horizontal shear, v, in pounds per square inch, at any point is:—

$$v = \frac{VA_1c}{It}$$

According to the usual approximate theory of shearing stresses in beams, the intensity of vertical shear at any point is equal to the intensity of horizontal shear at the same point.

The average intensity of shear throughout the area of the web of a beam equals $\frac{V}{Dt}$.

In a beam, the cross section of which is a rectangle, the maximum shearing stress is

$$v_{max.} = \frac{3V}{2A}$$

Short heavily loaded beams, special beams with thin webs, and plate girders are usually figured for web shear or buckling, column strength of the webs at concentrated loads and reactions, and for bending stresses.

BUCKLING STRESSES.

The shearing stresses acting in the web of a beam produce two stresses of equal intensity, compressive and tensile, respectively, acting at right angles to each other and at angles of 45 degrees with the Neutral Axis. The intensity of each of these stresses is equal to the intensity of the vertical shearing stress. The compressive stresses will tend to buckle the web which would, therefore, be figured as composed of a series of columns of a length equal to its diagonal depth.

Safe shearing and buckling stresses are discussed and explained, with formulas, on pages 93 and 94, which should be consulted for information on this subject.

VERTICAL DEFLECTION.

Deflections as usually calculated are based entirely on the extension and contraction of the beam fibers by the action of the Bending Moments due to the loads, not considering the deflections due to shear which are ordinarily inconsiderable.

The center deflection, d, of a beam due to bending stresses, within the elastic limit, produced by a uniformly distributed load, W, in pounds, is found from the formulas:—

$$d=\frac{5}{384}\,\frac{Wl^3}{EI}=\frac{5}{384}\,\frac{W(12L)^3}{EI}$$

When W is the safe uniformly distributed load corresponding to the Coefficient of Strength, C, the following relations exist between W and C and other properties of the section:—

$$W=\frac{C}{L},\ \text{and}\ C=\frac{2}{3}fS=\frac{2fI}{3n}$$

Substituting these values in the above formula:—

$$d=\frac{15fL^2}{nE}$$

For a uniformly distributed load and a fiber stress of 18,000 pounds per square inch, the center deflection, d, of a steel beam is given by the following formula:—

$$d=\frac{.01862L^2}{2n}$$

If the fiber stress is 16,000 pounds per square inch,

$$d = \frac{.01655L^2}{2n}$$

The deflections given in the two preceding formulas are based on the usual modulus of elasticity for steel of 29,000,000 pounds per square inch.

In the case of a beam, girder, or other section symmetrical about its Neutral Axis, 2n equals the depth, D, of the beam. The center deflection, in inches, of such a section under its safe uniformly distributed load which produces a fiber stress of 18,000 pounds per square inch, is given by the formula:—

$$d = \frac{0.01862L^2}{D} \text{ or very nearly } \frac{1}{54}\,\frac{L^2}{D}$$

For a fiber stress of 16,000 pounds per square inch, the deflection is

$$d = \frac{0.01655L^2}{D} \text{ or very nearly } \frac{1}{60}\,\frac{L^2}{D}$$

In terms of the Deflection Coefficients, H and H′, respectively, the maximum deflections, d and d′, are expressed by the following formulas:—

$$d = \frac{H}{2n} \qquad d' = \frac{H'}{2n}$$

Fiber Stress and Deflection Due to Impact. The approximate fiber stress and deflection due to a moving load falling on a beam supported at the ends are given by the following formulas:—

$$f'' = f\left(1 + \sqrt{\frac{2h}{d} + 1}\right) \text{ and } d'' = d\left(1 + \sqrt{\frac{2h}{d} + 1}\right)$$

in which,

f″ = Extreme fiber stress, in pounds per square inch, due to a falling load.

f = Extreme fiber stress, in pounds per square inch, due to the same load if at rest.

d″ = Deflection, in inches, due to a falling load.

d = Deflection, in inches, due to the same load if at rest.

h = Height of fall, in inches.

EXPLANATION OF TABLE OF DEFLECTION COEFFICIENTS.

A table of Deflection Coefficients, H and H′, is given on the following page. This table gives the values of the expressions, $H=0.01862L^2$, and $H'=0.01655\,L^2$ for spans from one to 60 feet.

The safe loads and corresponding deflections for other usual cases of loading, as compared with the safe uniformly distributed loads and the deflections therefor as given in the tables, are as stated in the deflection formulas which precede these notes. Deflections for various forms of loading are also given on pages 166 to 169 in connection with the diagrams.

The Deflection Coefficients, H and H′, furnish a convenient means for finding the deflection of steel beams under their uniformly distributed safe loads for any given maximum fiber stress within the elastic limit of the material.

To find the deflection of a simple steel beam, girder, or other steel section which is symmetrical about its Neutral Axis, under a uniformly distributed load, divide the Deflection Coefficient, H, or H′, in the following table for the given span by the depth of the beam in inches; the quotient will be the deflection in inches.

The Deflection Coefficients may be used to find the maximum deflection of a member used as a uniformly loaded beam, the section of which is not symmetrical about the Neutral Axis, provided it is symmetrical about a line perpendicular to the Neutral Axis.

To find the deflection of such a section, divide the Deflection Coefficient for the given span by twice the greatest distance, in inches, of the Neutral Axis from the extreme fiber of the cross section.

For uniformly distributed loads corresponding to other intensities of stress, the deflection can be found by simple proportion. Thus, for a uniformly distributed load producing a fiber stress of 12,000 pounds per square inch, the deflection will be $\frac{12,000}{18,000}$, or two-thirds, of that found by the use of the above coefficient, H, for 18,000 pounds per square inch.

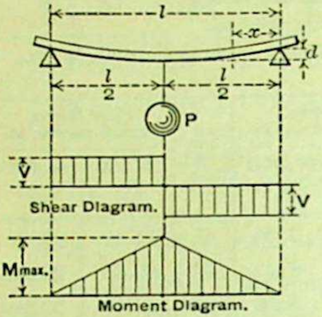
DEFLECTION COEFFICIENTS.

Beams supported at the ends
Load uniformly distributed.
Modulus of elasticity, E = 29,000,000 pounds per square inch.

Span in Feet.	Fiber Stress, Pounds per Sq. In.		Span in Feet.	Fiber Stress, Pounds per Sq. In.		Span in Feet.	Fiber Stress, Pounds per Sq. In.	
	18,000	16,000		18,000	16,000		18,000	16,000
	H	H′		H	H′		H	H′
1	.019	.017	21	8.21	7.30	41	31.30	27.82
2	.074	.066	22	9.01	8.01	42	32.85	29.20
3	.168	.149	23	9.85	8.76	43	34.43	30.60
4	.298	.265	24	10.73	9.53	44	36.05	32.04
5	.466	.414	25	11.64	10.34	45	37.71	33.52
6	.670	.596	26	12.59	11.19	46	39.40	35.02
7	.912	.811	27	13.57	12.07	47	41.13	36.56
8	1.192	1.059	28	14.60	12.98	48	42.90	38.14
9	1.508	1.341	29	15.66	13.92	49	44.71	39.74
10	1.862	1.655	30	16.76	14.90	50	46.55	41.38
11	2.253	2.003	31	17.89	15.91	51	48.43	43.05
12	2.681	2.383	32	19.07	16.95	52	50.35	44.76
13	3.147	2.797	33	20.28	18.02	53	52.31	46.49
14	3.650	3.244	34	21.52	19.13	54	54.30	48.26
15	4.190	3.724	35	22.81	20.28	55	56.33	50.07
16	4.767	4.237	36	24.13	21.45	56	58.39	51.91
17	5.381	4.783	37	25.49	22.66	57	60.50	53.78
18	6.033	5.363	38	26.89	23.90	58	62.64	55.68
19	6.722	5.975	39	28.32	25.18	59	64.82	57.62
20	7.448	6.621	40	29.79	26.48	60	67.03	59.59

DIAGRAMS AND FORMULAS FOR STATIC LOADS ON BEAMS.

P or W = Load in pounds.
l = Length in inches.
I = Moment of inertia, inches.^{4}
E = Modulus of elasticity, lbs. per sq. in.



I. SIMPLE BEAM.
SINGLE LOAD AT CENTER.

Safe load = ½ tabular load.

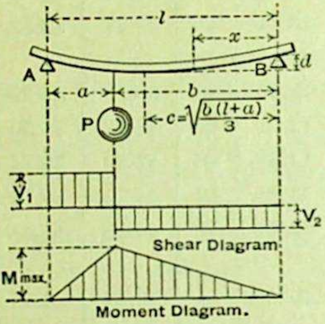
Shear at any point $=\frac{P}{2}$.

Maximum shear, $V=\frac{P}{2}$.

Bending moment at any point $=\frac{Px}{2}$
for $x=0$ to $x=\frac{l}{2}$ inclusive.

Bending moment at center, $M_{max.}=\frac{Pl}{4}$.

Maximum deflection, at center, $d=\frac{Pl^3}{48EI}$.



II. SIMPLE BEAM.
SINGLE LOAD AT ANY POINT.

NOTE: $b>a$.

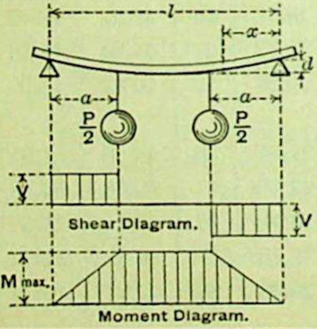
Safe load = tabular load $\times\frac{l^2}{8ab}$.

Shear at any point.
Between A and P, $V_1=\frac{Pb}{l}$.
Between B and P, $V_2=\frac{Pa}{l}$.

Bending moment at any point.
Between A and P, $M=\frac{Pb}{l}\,(l-x)$.
Between B and P, $M=\frac{Pax}{l}$.

Bending moment at P, $M_{max.}=\frac{Pab}{l}$.

Maximum deflection, $d=\frac{Pab\,(l+a)}{9EI}\cdot\frac{c}{l}$.



III. SIMPLE BEAM.
TWO SYMMETRICAL LOADS.

Safe load = tabular load $\times\frac{l}{4a}$.

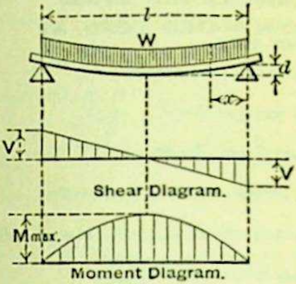
Shear at any point.
Between load and support, $V=\frac{P}{2}$.
Between loads, shear = 0.

Bending moment at any point.
Between load and support, $M=Vx$
for $x=0$ to $x=a$ inclusive.
Between loads, $M_{max.}=\frac{Pa}{2}$.

Maximum deflection, at center,
$$d=\frac{Pa}{48EI}\,(3l^2-4a^2).$$

DIAGRAMS AND FORMULAS FOR STATIC LOADS ON BEAMS.

P or W = Load in pounds.
l = Length in inches.
I = Moment of inertia, inches.^{4}
E = Modulus of elasticity, lbs. per sq. in.



IV. SIMPLE BEAM
UNIFORMLY DISTRIBUTED LOAD.

Safe load = tabular load.

Shear at any point $= \frac{W}{2l}(l-2x)$.

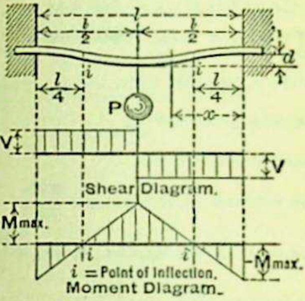
Maximum shear, at ends, $V = \frac{W}{2}$.

Bending moments.

At any point, $M = \frac{Wx}{2l}(l-x)$.

At center, $M_{max.} = \frac{Wl}{8}$.

Maximum deflection, at center,
$d = \frac{5}{384} \cdot \frac{Wl^3}{EI}$.



V. FIXED BEAM
SINGLE LOAD AT CENTER.

Safe load = tabular load.

Shear at any point $= \frac{P}{2}$.

Maximum shear, $V = \frac{P}{2}$.

Bending moments.

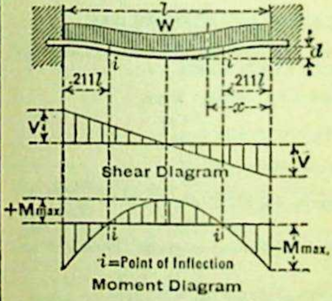
At any point, $M = \frac{P}{8}(4x-l)$

for $x = 0$ to $x = \frac{l}{2}$ inclusive.

At end, $-M_{max.} = -\frac{Pl}{8}$.

At center, $+M_{max.} = +\frac{Pl}{8}$.

Maximum deflection, at center, $d = \frac{Pl^3}{192EI}$.



VI. FIXED BEAM
UNIFORMLY DISTRIBUTED LOAD.

Safe load $= \frac{3}{2}$ tabular load.

Shear at any point $= \frac{W}{2l}(l-2x)$.

Maximum shear, at ends, $V = \frac{W}{2}$.

Bending moments.

At any point, $M = \frac{W}{12}\left(6x - l - \frac{6x^2}{l}\right)$.

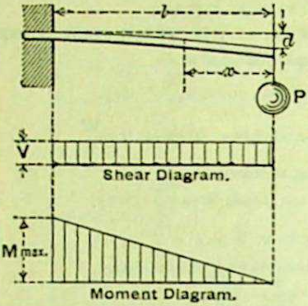
At end, $-M_{max.} = -\frac{Wl}{12}$.

At center, $+M_{max.} = \frac{Wl}{24}$.

Maximum deflection, at center, $d = \frac{Wl^3}{384EI}$.

DIAGRAMS AND FORMULAS FOR STATIC LOADS ON BEAMS.

P or W = Load in pounds.
l = Length in inches.
I = Moment of inertia, inches.^{4}
E = Modulus of elasticity, lbs. per sq. in.



VII. CANTILEVER BEAM.

CONCENTRATED LOAD AT FREE END.

Safe load = ⅛ tabular load.

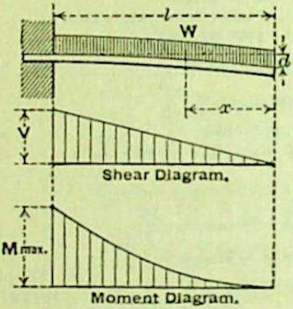
Shear at any point = P.

Maximum shear, V = P.

Bending moment at any point = Px.

Bending moment at support, $M_{max.} = Pl$.

Maximum deflection, $d = \frac{Pl^3}{3EI}$.



VIII. CANTILEVER BEAM.

UNIFORMLY DISTRIBUTED LOAD.

Safe load = ¼ tabular load.

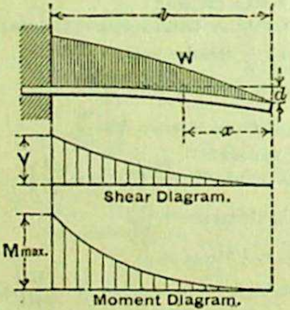
Shear at any point = $W\frac{x}{l}$.

Maximum shear, V = W.

Bending moment at any point = $\frac{Wx^2}{2l}$.

Bending moment at support, $M_{max.} = \frac{Wl}{2}$.

Maximum deflection, $d = \frac{Wl^3}{8EI}$.



IX. CANTILEVER BEAM.

LOAD INCREASING UNIFORMLY TO FIXED END.

Safe load = ⅜ tabular load.

Shear at any point = $\frac{Wx^2}{l^2}$.

Maximum shear, V = W.

Bending moment at any point = $\frac{Wx^3}{3l^2}$.

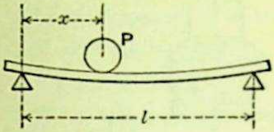
Bending moment at support, $M_{max.} = \frac{Wl}{3}$.

Maximum deflection, $d = \frac{Wl^3}{15EI}$.

DIAGRAMS AND FORMULAS FOR MOVING LOADS ON BEAMS.

NOTE: In the Case of Moving Loads Proper Allowance Should be Made for Impact.

P or p = Load in pounds. l, a or x = Distances in inches.
Bending moments are in inch pounds.

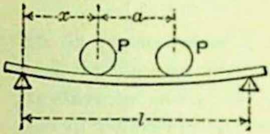


X. SIMPLE BEAM.

SINGLE CONCENTRATED MOVING LOAD.

Maximum shear = P occurs at end for $x = 0$.

Maximum bending moment $= \frac{Pl}{4}$ occurs at center for $x = \frac{l}{2}$.



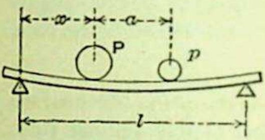
XI. SIMPLE BEAM.

TWO EQUAL CONCENTRATED MOVING LOADS.

Maximum shear $= \frac{2P}{l}\left(l - \frac{a}{2}\right)$ occurs at end for $x = 0$.

Maximum bending moment $M = \frac{P}{2l}\left(l - \frac{a}{2}\right)^2$ occurs under load at distance $x = \frac{1}{2}\left(l - \frac{a}{2}\right)$ from support.

If a is greater than $0.586\,l$, case No. X will give the maximum moment.



XII. SIMPLE BEAM.

TWO UNEQUAL CONCENTRATED MOVING LOADS.

Maximum shear $= P + p\,\frac{l-a}{l}$ occurs at end for $x = 0$.

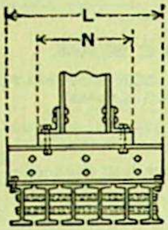
Maximum bending moment $= (P+p)\,\frac{x^2}{l}$ occurs under P at distance $x = \frac{1}{2}\left(l - \frac{pa}{P+p}\right)$ from left support.

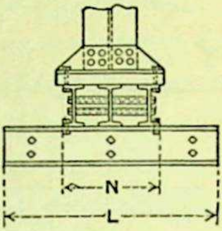
Maximum moment may occur for one load, as in case No. X.

General Rules for Maximum Shears and Moments in Simple Beams Carrying Moving Concentrated Loads.

The maximum shear due to moving concentrated loads always occurs at a support when a certain load is near that support. The maximum shear there equals the total reaction. The maximum bending moment due to moving concentrated loads occurs under one of the loads when this load is as far from one support as the center of gravity of all the loads on the beam is from the other support.

GRILLAGE BEAMS IN FOUNDATIONS.





In the design of foundations, where it is necessary to distribute column loads properly upon the soil and at the same time eliminate large masses of masonry and deep excavations, it is usual to employ grillages of steel beams imbedded in concrete. One, two, or three tiers of beams may be used, depending on the magnitude of the load and the bearing value of the soil.

The distance between the adjacent edges of the beam flanges should not be more than three times the flange width nor less than 2½ inches, so that the spaces between the beams can be thoroughly filled with concrete. Pipe separators should be used to keep the beams properly spaced.

The concrete serves both to assist in distributing the load on the soil and as a protection for the steel beams against rust. In a conservative design, the concrete would not be considered as offering any resistance to the buckling of the beam webs.

The grillage area required to distribute a given column load is equal to the total load divided by the allowable unit bearing pressure upon the soil. The load supported by each beam in any tier is equal to the total load divided by the number of beams in that tier.

To determine the size of beams for use in each tier, let

D = Depth of beam, in inches.
f = Allowable unit stress in bending, in pounds per square inch.
h = Clear distance between flanges, in inches.
L = Length of beam, in feet.
N = Length on which load is applied, in feet.
t = Thickness of web, in inches.
V = Greatest safe allowable shear on web of beam, in pounds.
$V_{max.}$ = Maximum shear due to the load W, in pounds.
W = Load supported by each beam in one tier, in pounds.

The maximum Bending Moment occurs at the center of the beam and is equal to $\frac{W(L-N)}{8}$, in foot pounds.

By using the length $(L-N)$ as the span, the size of, or safe load on grillage beams may be obtained directly from the tables of safe loads for I beams. If $(L-N)$ is less than the spans given in the tables, the size of the grillage beam is obtained by the determination of its required Coefficient of Strength or Section Modulus.

The required Coefficient of Strength, C, is

$$C = W(L-N) \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

The required Section Modulus, S, is

$$S = \frac{3W(L-N)}{2f} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

The maximum shear, $V_{max.}$, on one grillage beam occurs below the edge of the column base and is obtained by the formula

$$V_{max.} = \frac{W(L-N)}{2L} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

The maximum shear, $V_{max.}$, must not exceed the allowable shear, V, which is obtained by one of the following formulas:—

When the buckling of the web is prevented,

$$V = 12{,}000\ D\,t$$

When the web is regarded as without lateral support,

$$V = \frac{13{,}500Dt}{1 + \frac{h^2}{3000t^2}}$$

with a maximum value of 12,000 D t.

Tables of the allowable Maximum Safe Shear for Bethlehem Girder Beams and I Beams are given on pages 95 and 96.

The extent and distribution of the buckling stress in the web of a grillage beam directly under the column is a matter which also should be considered. It is often assumed that the buckling stress is distributed over a portion of the web bounded between planes extending downwardly and outwardly from the edges of the column or base plate, at an angle of 45 degrees, or less, with the direction of the load.

In selecting a grillage beam, use formula (1) or (2) to find the required Coefficient of Strength or Section Modulus, and formula (3) to find the required shearing or buckling strength. The proper beam should satisfy both of these requirements.

Column Bases. Rolled steel slabs are generally preferred to cast iron or built-up column bases. Slabs require less depth and, therefore, less excavation; rolled steel is a more reliable material than cast iron; and slabs require little or no fabrication as compared with riveted column bases.

Rolled steel slabs are, therefore, safer and more economical than other types of column bases, and because of their manufacture by a simple rolling process, can be delivered more promptly.

Further information relating to this subject is presented in a booklet entitled "Bethlehem Rolled Steel Slabs for Column Bases," which gives data relating to the sizes of slabs, approximate weights, requirements for planing and fabrication, tolerances, and instructions for ordering.

Tables are also presented in this booklet giving the safe loads, in thousands of pounds, on rolled steel slabs of different sizes figured for various unit pressures on their supports.

WALL BEARING PLATES FOR BETHLEHEM GIRDER BEAMS AND BETHLEHEM I BEAMS.

Steel bearing plates are used under the ends of steel beams and girders resting on walls to distribute the pressure on the latter. The plates must have sufficient bearing area so that the allowable safe pressures on walls of different kinds will not be exceeded.

The size of the bearing plate must first be determined by the area required to distribute the pressure, and its thickness is then obtained by the formula given below.

NOTATION.

B = Width of flange of beam, in inches.

f = Allowable bending stress in the bearing plate, in pounds per square inch.

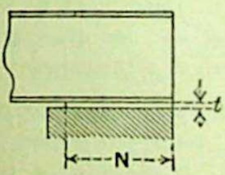
M = Overall dimension of the bearing plate in a direction perpendicular to the longitudinal axis of the beam, in inches.

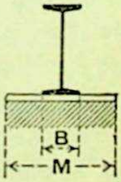
N = Overall dimension of the bearing plate in the direction of the longitudinal axis of the beam, in inches.

R = Reaction at point of support, in pounds.

t = Thickness of plate, in inches.

w = Unit pressure on masonry, in pounds per square inch.





$$w = \frac{R}{MN}$$

$$t = \frac{1}{2}(M - B)\sqrt{\frac{3w}{f}}$$

SAFE BEARING VALUES FOR WALL PLATES ON MASONRY.

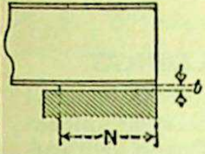
Kinds of Masonry.	Pounds per Square Inch.	Tons per Square Foot.
Rubble, Portland Cement Mortar	200	14.4
Rubble, Lime and Cement Mortar	150	10.8
Hard Brick, Cement Mortar	300	21.6
Common Brick, Cement Mortar	250	18.0
Common Brick, Lime and Cement Mortar	150	10.8
Sandstone, Cement Mortar	400	28.8
Limestone, Cement Mortar	500	36.0
Granite, Cement Mortar	800	57.6
Portland Cement Concrete	500	36.0

Note:—The above bearing values are for masonry of good materials and workmanship.

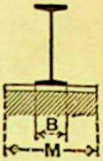
The dimensions M and N of the bearing plates shown in the table on page 175 are based on stresses of 200 to 250 pounds per square inch for bearing on the masonry, and a bending stress not exceeding 18,000 pounds per square inch in the beams and plates. To support reactions greater than those given in the table, and properly distribute the loads on the masonry, heavier plates or beam grillages should be used.

Frequently a template of bluestone or other hard stone is used instead of a steel bearing plate. Where the load to be supported is considerable, as under the ends of girders, both steel bearing plates and stone templates may be used, in which case the size of the bearing plate is determined by the allowable pressure on the stone template according to the safe pressure for the kind of stone used. The size of the stone template must also be sufficient to limit the pressure on the brickwork or other masonry to the safe allowable value given in the above Table of Safe Bearing Values for Wall Plates on Masonry.

The stone should not project beyond the steel bearing plate in any direction more than ¾ of the thickness of the stone. For extreme pressures a grillage composed of a number of small beams or channels should be used. These should be placed close together, maintained in relative position with pipe separators, and, where necessary to distribute the load properly to the masonry, they should be provided with bottom plates.



WALL BEARING PLATES FOR BETHLEHEM GIRDERS AND I BEAMS.



Section Number.	Depth of Beam, Inches.	Weight of Beam per Foot, Pounds.	SIZE OF BEARING PLATE.			Safe Reaction, Thousands of Pounds.	Minimum Span, Feet.	Weight of Plate, Pounds.
			N Inches.	M Inches.	t Inches.			
G30	30	190.0	24	20	1	115	30.1	136
G28	28	165.0	24	20	1	100	28.2	136
G26	26	151.0	24	20	1	92	26.3	136
G24a	24	141.0	24	20	1	85	24.5	136
G24	24	121.0	24	20	1	74	24.1	136
G20a	20	142.0	24	20	1	80	22.1	136
G20	20	113.0	24	20	1	72	19.5	136
G18	18	93.0	16	16	⅞	64	16.6	64
G15b	15	141.0	16	17	1	68	18.5	77
G15a	15	105.0	16	17	1	67	14.6	77
G15	15	74.0	16	16	⅞	56	12.6	64
G12a	12	70.5	12	16	⅞	38	14.0	48
G12	12	55.5	12	16	⅞	37	11.7	48
G10	10	44.5	10	12	⅝	30	9.8	21
G 9	9	38.5	10	12	⅝	27	8.5	21
G 8	8	33.0	10	12	⅝	23	7.3	21
B30	30	121.0	20	16	1	80	26.1	91
B28	28	106.0	20	16	1	80	21.4	91
B26	26	91.0	16	16	1	59	23.1	72
B24b	24	99.5	16	15	⅞	56	25.0	60
B24a	24	84.5	16	15	⅞	51	23.3	60
B24	24	73.5	16	15	⅞	49	21.4	60
B22	22 1/16	68.5	16	15	⅞	45	19.5	60
B20a	20	73.0	16	15	⅞	47	18.7	60
B20	20 1/16	62.0	16	15	⅞	42	17.5	60
B18a	18	69.0	16	15	⅞	47	15.6	60
B18	18 1/16	52.0	16	15	⅞	39	14.2	60
B15b	15	71.5	12	12	¾	36	17.6	31
B15a	15	54.5	12	12	¾	32	15.0	31
B15	15 1/32	40.0	12	12	¾	31	11.8	31
B12a	12	36.5	12	10	⅝	24	11.3	21
B12	12	28.5	12	10	⅝	24	9.0	21
B10	10	23.5	8	8	½	13	11.3	9
B 9	9	20.5	8	8	½	13	8.8	9
B 8	8	17.5	8	8	⅜	11	7.7	7

WIND STRESSES IN TALL BUILDINGS.

All buildings should have adequate provision for resisting wind pressure. Walls, floors and partitions afford a certain amount of resistance, but, in high buildings, the thin walls and light partitions used in modern construction are insufficient for the purpose, and special provision to resist the stresses caused by wind should be made in the steel framing.

Steel columns for tier buildings should be used in lengths of two or more stories and spliced with sufficient plates and rivets to make them continuous with respect to transverse bending. All column splices and the connections of girders and beams to the columns should be riveted. With a properly constructed steel frame of this kind, such as is shown on pages 142 and 145, special wind bracing will seldom be needed, unless the height of the building is more than twice its least base.

Higher buildings will usually require wind bracing of some form, and as it is seldom possible to use diagonal rods between the columns, other forms of bracing, like those shown on page 143, may be used. Bethlehem H columns, as shown by the illustrations on pages 142 to 149, afford every facility for the construction of an ideal steel frame for buildings.

Unless specified otherwise by building codes, it is now considered good practice to provide for a horizontal wind pressure of not less than twenty pounds per square foot on the vertical projection of exposed surfaces during erection, and fifteen pounds per square foot on the vertical projection of the finished structure.

The total live, dead and wind loads should not produce stresses exceeding those of the combined dead and live loads by more than 33⅓ per cent.

Wind increases the compression in the leeward columns, and also produces bending in the columns and girders, all of which effects must be considered.

Exact methods, on account of their complexity, are rarely used for the calculation of wind stresses in building frames.

Several approximate methods are in use, and are based on the general assumption that a building bent acts as a cantilever beam fixed in the ground. The wind loads are applied horizontally, and the transverse shear in any story is distributed among the columns of the bent. The direct and bending stresses in the columns and girders due to the wind pressure are then found by the principles of statics. The variation in methods is due primarily to the different assumptions of shear distribution among the columns and the location of the points of contraflexure.*

CANTILEVER METHOD.

The cantilever method is representative of the approximate methods for calculating wind stresses and, as modified below, is based on the following assumptions: (1) All columns in any given story have equal sections, and the direct stresses in the columns due to wind are proportional to the distances of the columns from the Neutral Axis of the bent; (2) the point of contraflexure of each column is at mid-height of the story, and the point of contraflexure of each girder is at its mid-length; (3) the resultant of the wind pressure acting between two successive points of contraflexure is applied at the intersection of column and girder; (4) the joints are perfectly rigid.

NOTATION.

A, B, C, D, E, ...L,... etc. = Spans, in feet.

a, b, c, d, d′, etc. = Distances of columns Nos. 1, 2, 3, 4, 5, etc., from the Neutral Axis of bent, feet.

H = Distance from mid-height of the story under consideration to the top of the building, feet.

h_1 = Height of the story under consideration, feet.

h_2 = Height of story above, feet.

$h = \frac{h_1}{2} + \frac{h_2}{2}$.

W = Wind load acting on height H, pounds.

P = Wind load acting on story height h, pounds.

l = Distance from mid-height of the story under consideration to the center of gravity of the wind load W.

M_A, M_B, M_C, M_D, etc. = Bending Moments at ends of girders in the corresponding spans A, B, C, D, etc., foot-pounds.

M_1, M_2, M_3, M_4, etc. = Bending Moments of corresponding columns Nos. 1, 2, 3, 4, etc., at top and bottom of story under consideration, foot-pounds.

D_1, D_2, D_3, D_4, etc. = Direct stresses in the corresponding columns Nos. 1, 2, 3, 4, etc., in story under consideration, pounds.

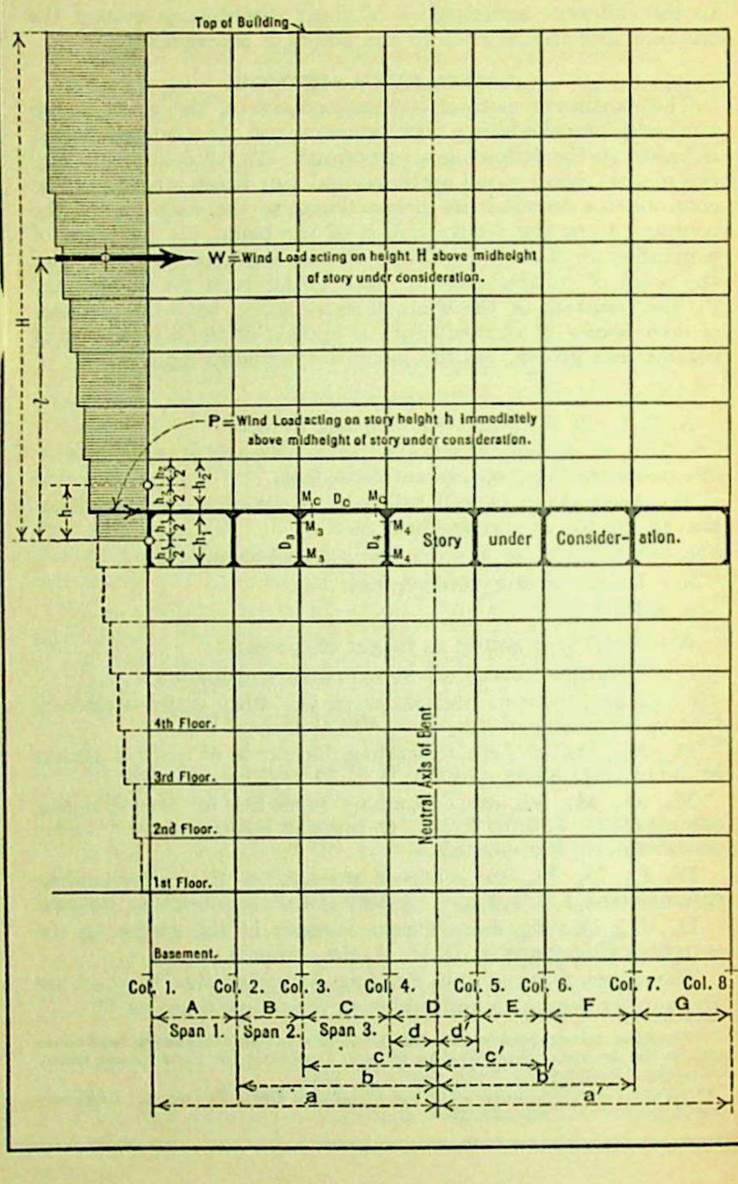
D_A, D_B, D_C, D_D, etc. = Direct stresses in the girders in the corresponding spans A, B, C, D, etc., pounds.

The direct stresses and Bending Moments due to wind are given in the formulas and tables on the following pages.**

---

* Detailed descriptions of these methods may be found in current text-books and in the article, "Windbracing without Diagonals for Steel-Frame Office-buildings," Engineering News, March 13, 1913.

** "Tables and Formulas for Wind Stresses in Office Buildings," Engineering News-Record, Sept. 28, 1922.


Top of Building
W = Wind Load acting on height H above midheight of story under consideration.
P = Wind Load acting on story height h immediately above midheight of story under consideration.
H
l
h
h2/2
h2/2
h2
h1/2
h1/2
h1
M_C
D_C
M_C
M_3
D_3
M_3
M_4
D_4
M_4
Story under Consider-ation.
4th Floor.
3rd Floor.
2nd Floor.
1st Floor.
Basement.
Neutral Axis of Bent
Col. 1.
Col. 2.
Col. 3.
Col. 4.
Col. 5.
Col. 6.
Col. 7.
Col. 8
A
B
C
D
E
F
G
Span 1.
Span 2.
Span 3.
d
d′
c
c′
b
b′
a
a′

I. UNSYMMETRICAL BUILDING BENT.
VARYING OR UNIFORM WIND PRESSURE.

Most building codes specify a uniform wind pressure for the full height of a building, but those of some cities, like Philadelphia and Boston, specify wind pressures, the magnitudes of which increase upwardly from a certain elevation.

The general formulas given below will apply in any case, but their use will be greatly simplified if the wind pressure is uniform, as generally specified. For uniform wind pressure the lever arm, l, of the wind load W becomes equal to half the height H.

In order to find the Bending Moments and direct stresses due to the wind load, proceed as follows:—

(1) Locate the position of the Neutral Axis of the bent, so that

$$a+b+c+d+\dots\dots\dots = a'+b'+c'+d'+\dots\dots\dots\dots$$

then calculate the quantity Q:

$$Q=(a)^2+(a')^2+(b)^2+(b')^2+(c)^2+(c')^2+(d)^2+(d')^2+\dots.$$

(2) Calculate, for the floor under consideration, the constant factors p, q, r and t.

$$p=\frac{2Wh-Ph_2}{4Q}, \qquad q=\frac{Wh_1}{2Wh-Ph_2}, \qquad r=\frac{Wl}{Q}, \qquad t=\frac{2P}{Wh_1}.$$

$$q'=\frac{W}{2W-P}$$ {Where the difference between h_1 and h_2 is negligible.

(3) Find the moments at the ends of the girders, as follows:

$M_A=p\,Aa$
$M_B=p\,B(a+b)$
$M_C=p\,C(a+b+c)$
$M_D=p\,D(a+b+c+d)=p\,D(a'+b'+c'+d')$
$M_E=p\,E(a+b+c+d-d')=p\,E(a'+b'+c')$

……

(4) Find the moments at the ends of the columns, as follows:

$M_1=q\,M_A$
$M_2=q\,(M_A+M_B)$
$M_3=q\,(M_B+M_C)$
$M_4=q\,(M_C+M_D)$
$M_5=q\,(M_D+M_E)$

……

(5) Find the direct stresses in the columns, as follows:

$D_1=ra$
$D_2=rb$
$D_3=rc$
$D_4=rd$
$D_5=rd'$

……

(6) Find the direct stresses in the girders, as follows:

$D_A=P-tM_1$
$D_B=D_A-tM_2$
$D_C=D_B-tM_3$
$D_D=D_C-tM_4$
$D_E=D_D-tM_5$

……

The direct stresses in the columns are tensile (+) on the windward side and compressive (−) on the leeward side of the Neutral Axis of the building bent.

The direct stresses in the girders are compressive stresses. In stories for which P is the same, the direct stresses in corresponding girders are generally the same.

II. BUILDING BENT WITH EQUAL SPANS, L.

UNIFORM WIND PRESSURE.

NOTE: The wind load below the story under consideration does not affect the calculations and need not be uniform. If the story under consideration is below ground level, where all or part of $P = 0$, use the formulas for varying wind pressure.

In order to find the Bending Moments and direct stresses due to the wind load, proceed as follows:

(1) Find the moments at the ends of the girders, taking the coefficients K_1 from the table below.

$$M = K_1 P(2H - h_2)$$

Number of Spans in Bent.	VALUES OF COEFFICIENTS K_1.									
	Span 1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7	Span 8	Span 9	Span 10
1	¼									
2	⅛	⅛								
3	3/40	4/40	3/40							
4	2/40	3/40	3/40	2/40						
5	5/140	8/140	9/140	8/140	5/140					
6	3/112	5/112	6/112	6/112	5/112	3/112				
7	7/336	12/336	15/336	16/336	15/336	12/336	7/336			
8	4/240	7/240	9/240	10/240	10/240	9/240	7/240	4/240		
9	9/660	16/660	21/660	24/660	25/660	24/660	21/660	16/660	9/660	
10	5/440	9/440	12/440	14/440	15/440	15/440	14/440	12/440	9/440	5/440

(2) Find the moments at the ends of the columns, taking the coefficients K_2 from the table below.

$$M = K_2 W h_1$$

Number of Spans in Bent.	VALUES OF COEFFICIENTS K_2.										
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
1	¼	¼									
2	⅛	¼	⅛								
3	3/40	7/40	7/40	3/40							
4	2/40	5/40	6/40	5/40	2/40						
5	5/140	13/140	17/140	17/140	13/140	5/140					
6	3/112	8/112	11/112	12/112	11/112	8/112	3/112				
7	7/336	19/336	27/336	31/336	31/336	27/336	19/336	7/336			
8	4/240	11/240	16/240	19/240	20/240	19/240	16/240	11/240	4/240		
9	9/660	25/660	37/660	45/660	49/660	49/660	45/660	37/660	25/660	9/660	
10	5/440	14/440	21/440	26/440	29/440	30/440	29/440	26/440	21/440	14/440	5/440

(3) Find the direct stresses in the columns, taking the coefficients K_3 from the table below.

$$D = K_3 W \frac{H}{L}$$

Number of Spans in Bent.	VALUES OF COEFFICIENTS K_3.										
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
1	1/2	-1/2									
2	1/4	0	-1/4								
3	3/20	1/20	-1/20	-3/20							
4	2/20	1/20	0	-1/20	-2/20						
5	5/70	3/70	1/70	-1/70	-3/70	-5/70					
6	3/56	2/56	1/56	0	-1/56	-2/56	-3/56				
7	7/168	5/168	3/168	1/168	-1/168	-3/168	-5/168	-7/168			
8	4/120	3/120	2/120	1/120	0	-1/120	-2/120	-3/120	-4/120		
9	9/330	7/330	5/330	3/330	1/330	-1/330	-3/330	-5/330	-7/330	-9/330	
10	5/220	4/220	3/220	2/220	1/220	0	-1/220	-2/220	-3/220	-4/220	-5/220

The direct stresses in the columns are tensile (+) on the windward side and compressive (−) on the leeward side of the Neutral Axis of the building bent.

(4) Find the direct stresses in the girders, taking the coefficients K_4 from the table below.

$$D = K_4 P$$

Number of Spans in Bent.	VALUES OF COEFFICIENTS K_4.									
	Span 1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7	Span 8	Span 9	Span 10
1	1/2									
2	3/4	1/4								
3	17/20	10/20	3/20							
4	18/20	13/20	7/20	2/20						
5	65/70	52/70	35/70	18/70	5/70					
6	53/56	45/56	34/56	22/56	11/56	3/56				
7	161/168	142/168	115/168	84/168	53/168	26/168	7/168			
8	116/120	105/120	89/120	70/120	50/120	31/120	15/120	4/120		
9	321/330	296/330	259/330	214/330	165/330	116/330	71/330	34/330	9/330	
10	215/220	201/220	180/220	154/220	125/220	95/220	66/220	40/220	19/220	5/220

The direct stresses in the girders are compressive stresses. In stories for which P is the same, the direct stresses in corresponding girders are the same.

FLOORS AND FIREPROOFING.

Floors. Buildings of fireproof construction consist essentially of a steel frame or skeleton to support the floors and, in the case of high buildings, the outside walls also are carried by the steel framing. All parts of the steel work are enclosed and protected by some fire-resisting material which should be of such quality and arrangement as not to disintegrate or fall away when heated to high temperatures and at the same time exposed to a stream of cold water. The fireproofing for the floors, in addition to its ability to afford a fireproof protection to the steel beams, must be capable of supporting the load and distributing it to the floor beams and girders which, in turn, transmit it to the columns and thence to the foundations.

One of the earlier forms of floor support consisted of brick arches built between, and carried by, the bottom flanges and lower portions of the web of iron or steel I beams, but this style had considerable dead weight and, as ordinarily constructed, did not provide fireproof protection for the bottom flanges of the beams, and for these reasons is now seldom used.

Another of the earlier forms of floor support was composed of sheets of corrugated iron or steel arched between the beams, on which a concrete filling was placed, and this also, as ordinarily constructed, did not provide protection for the bottom flanges of the beams and was unnecessarily heavy.

A later style of floor support is the hollow tile system, which is composed of flat or segmental arches constructed of moulded tile of hard burned clay, specially shaped, and of various depths to suit different loads and the sizes of the I beams supporting them.

Various other systems of fireproof floors and fireproofing are now in use, the most usual forms of which consist of reinforced concrete in solid slabs or in combination with hollow tile.

There are also several systems of wide span construction, reinforced in one or two directions between steel girders.

Fireproofing the Steel Frame. Column or girder fireproofing may be accomplished by the use of hollow tile, shaped to fit and enclose the steel work, or the steel may be encased in concrete properly reinforced to prevent its dislodgment in case of fire. Where H-shaped steel columns are used, the space between the fireproofing shell and the web of the column should be filled with hollow tile or concrete.

Partitions. Fireproof partitions may be constructed of hollow tile composed of burned clay, to which the plaster finish may be directly applied, or they may be composed of suitable metal studding on which is secured the wire-cloth or metal lath that serves to support the concrete or other fireproofing, the surface then being plastered in the usual manner.

Furring. As a protection for the plastering and the interior against dampness, the inner surfaces of the outer brick walls are often covered with split tile furring, about 2 inches thick.

Roofs. Book tile laid on a structural steel roof frame is employed especially when the roof is to be covered with concrete, tar compositions or other forms of roofing. This type of tile is also used in roof construction without any superficial covering when only a light roof is desired.

Weights of Hollow Tile Floor Arches, etc. On the following page are given Weights of Hollow Tile Floor Arches and Fireproof Materials. The dead weights of fireproof floors vary between wide limits dependent upon the system employed, the load to be carried and the distance between the supporting beams. When the arch is raised, so that its upper surface is at or near the tops of the beams, and the skews have a depth greater than the inters and keys, it is necessary to add to the average weight of the arch an amount equal to the difference in the weight of the raised skew and a skew of the same depth as the inters and keys.

Hollow Tile in Floor Construction. Typical drawings of several types of hollow tile in floor construction are presented on page 185.

WEIGHTS OF HOLLOW TILE FLOOR ARCHES AND FIREPROOF MATERIALS.

AS GIVEN BY MANUFACTURERS OF THIS MATERIAL.

Depth of Arch in Inches.	AVERAGE WEIGHT, POUNDS PER SQUARE FOOT.				
	Flat Arches. Using Side Keys and End Inters.		Segmental Arches.		
	Type No. 1 With Side Skews.	Type No. 2 With End Skews.	East.	West.	Ohio.
6	26	26	30	32	35
8	32	32	Using Eastern Tile.	Using Western Tile.	Using Ohio Tile.
9	36	36			
10	40	39			
12	48	44			
14	54	51			
15	56	53			
16	58	55			

For Raised Skews the weights are greater as noted on page 183.

STANDARD HOLLOW TILE FOR PARTITIONS, ETC.

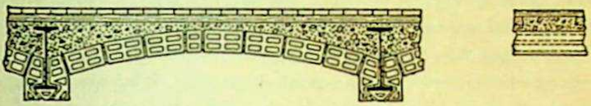
Size in Inches.	Number of Cells.	Weight of One Tile, in Pounds.
3 x 12 x 12	3	15
4 x 12 x 12	3	16
6 x 12 x 12	3	22
6 x 12 x 12	6	24
8 x 12 x 12	4 or 6	30
10 x 12 x 12	4 or 6	36
12 x 12 x 12	4 or 6	40

2 x 12 x 12 inches Split Furring, 9 Pounds each.

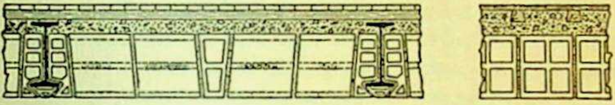
3 x 12 x 18 to 24 inch Book Tile, 18 Pounds per Square Foot.

Note:—To compute the approximate weight of any hollow burned clay tile, multiply its volume, in cubic inches, by 0.07 for surface clays and by 0.08 for shales or Ohio fire clays, and the result will be in pounds.

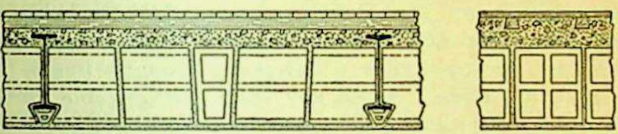
HOLLOW TILE IN FLOOR CONSTRUCTION.



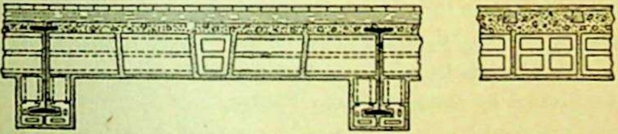
SEGMENTAL ARCH.



FLAT ARCH, TYPE NO. 1, SIDE KEYS, END INTERS AND SIDE SKEWS.



FLAT ARCH, TYPE NO. 2, SIDE KEYS, END INTERS AND END SKEWS.



FLAT ARCH, RAISED ON FLOOR BEAMS.

SAFE LOADS FOR FLAT AND SEGMENTAL FLOOR ARCHES OF HOLLOW TILE.

The Table of Safe Loads for Flat Floor Arches given on page 187 is applicable to all shapes of tile. The areas given are obtained by passing a plane through the arch blocks at right angles to the span and are areas for a 1-foot width of arch. Generally speaking, hollow tile of various shapes, but of the same depth and cross sectional area, have equal strength. The strengths of arches of equal depth are, therefore, directly proportional to their net sectional areas.

The strength of any arch depends as much upon the workmanship as upon the material. The spans given in the table are safe if the arches are properly set. The Building Codes of various cities do not agree in their requirements for the lengths of spans, safe loads and depths of tile floor arches for different classes of buildings, so that the proper code should be consulted when a design is being made.

The safe loads in the tables have been calculated for Flat Tile Arches using end construction inters and side construction keys in combination with side construction skews and also with end construction skews. The net sectional areas of the tile indicated are for the keys at the center of the arch which are subjected to the greatest stress, and these net areas are taken per foot of tile parallel to the beams. Inters is a trade term or abbreviated name for the tiles between the end skews or skew backs and the center key.

The weights of the arches have not been deducted from their safe loads in the following Table of Safe Loads for Flat Floor Arches, so these weights and the other dead loads must be deducted to obtain the net safe live loads for any arch and span.

When the Safety Factor is other than 7, which is that given in the tables, the safe load is equal to 7 times the load given in the tables divided by the new Safety Factor.

When the net cross sectional area of the key is other than that given in the Flat Arch Table, the total load on the arch will bear the same ratio to the safe tabular load plus arch weight per square foot as the net cross sectional area bears to the tabular net cross sectional area.

Example:—What will a 10-inch arch carry with a factor of safety of 7 for a span of 6 feet 6 inches, the keys having a thickness of ⅝ inch in their shells and webs, and being three cells in depth?

⅝ x 12 x 4 = 30 square inches net = Actual area of key.
Area of 10-inch tile in table = 36 square inches.
30 ÷ 36 = 0.833 Ratio of Actual Area to Tabular Area.
Safe load in Table = 198 pounds x 0.833 = 165 pounds =
= Safe Live and Dead Load for the Actual Area.

Assuming 38 pounds as the weight of arch, then 165 − 38 = 127 pounds, which is the net Safe Live Load.

SAFE LOADS FOR SEGMENTAL FLOOR ARCHES OF HOLLOW TILE.

AS GIVEN BY MANUFACTURERS OF THIS MATERIAL.

Safety Factor = 7.

Weight of Arch Blocks not included.

Arch.		Depth of Arch = 6 Inches.					
		Area of Arch = 36 Square Inches.					
		Rise of Arch, in Inches.					
		¾	1	1¼	1½	1¾	2
Spans.		Safe Loads.					
Feet.	Inches.	Pounds per Square Foot.					
4	0	902	1148	1485	1740	1986	2233
4	6	792	1044	1313	1539	1775	1975
5	0	709	951	1172	1379	1592	1773
5	6	641	864	1062	1266	1439	1619
6	0	585	788	969	1154	1315	1476
6	6	551	724	902	1058	1218	1358
7	0	508	669	834	981	1127	1264
7	6	471	621	774	920	1049	1176
8	0	439	588	724	859	987	1099
8	6	411	551	678	806	926	1037
9	0	386	518	645	758	871	977
9	6	364	489	608	721	823	923
10	0	344	462	576	683	784	879

SAFE LOADS FOR FLAT FLOOR ARCHES OF HOLLOW TILE.

AS GIVEN BY MANUFACTURERS OF THIS MATERIAL.

Safety Factor=7.

Total Dead and Live Load.

Arch.		Depth in Inches.					
		6	8	9	10	12	15
		Net Sectional Area, Square Inches.					
		27	27	27	36	36	36
Spans.		Safe Loads.					
Feet.	Inches.	Pounds per Square Foot.					
3	0	420	560	630	933	1120	1400
3	3	357	477	537	795	954	1193
3	6	308	411	462	685	823	1028
3	9	268	358	403	597	716	895
4	0	236	315	354	525	630	786
4	3	..	279	314	465	558	697
4	6	..	249	279	415	497	622
4	9	..	223	251	372	447	558
5	0	..	201	227	336	402	504
5	3	..	182	205	305	365	457
5	6	..	..	187	277	333	417
5	9	..	..	171	254	305	381
6	0	..	..	157	233	280	350
6	3	..	..	..	214	258	322
6	6	..	..	..	198	238	298
6	9	..	..	..	..	221	276
7	0	..	..	..	..	206	257
7	6	..	..	..	..	178	223
8	0	..	..	..	..	157	197
8	6	..	..	..	..	..	174
9	0	..	..	..	..	..	155
9	6	..	..	..	..	..	140
10	0	..	..	..	..	..	126

THRUST OF FLOOR ARCHES.

Horizontal Thrust. Hollow tile or other arch construction for floors causes lateral thrusts which must be taken care of in order to eliminate excessive stresses in the supporting beams or member

Although, in the completed structure, the horizontal thrusts of adjoining arches may counterbalance each other, tie rods should be used and should be so proportioned and spaced as to withstand the entire thrust of the arches, thus tying the structure together and facilitating the construction.

The horizontal thrust of segmental floor arches, on the assumption of uniform loading, may be found by the following formula:—

$$p = \frac{3wL^2}{2R}$$

in which,

p = Pressure, or thrust, in pounds per lineal foot of arch.
w = Load on arch, in pounds per square foot, uniformly distributed.
L = Span of arch, in feet.
R = Rise of segmental arch, in inches.

For a concentrated load at the center, of weight P, in pounds, the thrust,

$$p = \frac{3PL}{R}$$

For arches with flat tops and bottoms, such as are used in floors, the voussoir joints on each side of the central key are usually laid out on parallel lines, and in these cases the thrust may be determined approximately by using for R, in the above formula, the effective depth or rise of the arch which, as indicated in the table on the next page, is usually assumed to be equal to the depth of the arch less 2.4 inches.

For segmental arches, the rise, R, is the vertical distance from the highest part of the intrados to the plane of the springing line. If the radius of the intrados for segmental arches is r, the rise may be obtained from the following formula:—

$$R = r - \sqrt{r^2 - \frac{L^2}{4}}. \quad \text{Conversely,} \quad r = \frac{R}{2} + \frac{L^2}{8R}.$$

As noted under the caption:—Beams Laterally Unsupported, on page 75, care should be taken that the spacing of the tie rods is not greater than fifteen times the least flange width, otherwise the safe loads should be reduced to compensate for the deformations produced by flexure due to compression of the upper flange considered as a column.

Spacing of Tie Rods for Tile Arches. The table on the following page has been computed with the use of the formula given below which was obtained from that on page 189 giving the thrust of arches.

NOTATION.

a = Net area of one rod, in square inches.
L = Span of arch, in feet.
p = Pressure or thrust, in pounds per lineal foot of arch.
R = Rise of arch, in inches.
s = Spacing of tie rods, in feet.
w = Total load, in pounds per square foot of arch.

The resistance of one tie rod, in pounds, is equal to $a \times 18{,}000$, and as this acts along a width of arch, s, equal to the distance between tie rods, the total thrust of the arch resisted by the tie rod is equal to $s \times p$. Using the value of p given on page 189, the following formula is derived:—

$$18{,}000\,a = sp = s\frac{3wL^2}{2R}$$

$$s = \frac{12{,}000aR}{wL^2}$$

This formula gives the spacing of tie rods corresponding to a tensile stress in the net area of the rods of 18,000 pounds per square inch.

The following table gives the usual sizes of tie rods and their net areas.

Diameter of Rod, Inches.	⅝	¾	⅞	1
Net Area, Square Inches.	0.202	0.302	0.420	0.550

In spacing tie rods, the lateral strength of the beams, to resist flexure due to the thrust of the arches, should be taken into consideration; explanations for which are given on pages 84 to 92.

SPACING OF TIE RODS FOR HOLLOW TILE ARCHES.

TYPE NO. 1.

SPACING, IN FEET, FOR A UNIFORM LOAD OF 100 POUNDS PER SQUARE FOOT IN ADDITION TO THE WEIGHT OF THE ARCH.

Span of Arch, Feet.	Diameter of Tie Rods, Inch.	Nominal Depth of Arch, Inches.							
		6	8	9	10	12	14	15	16
		Effective Depth or Rise of Arch, Inches.							
		3.6	5.6	6.6	7.6	9.6	11.6	12.6	13.6
3	⅝	7.70	11.43	13.07	14.62	17.47	20.29	21.75	23.18
3	¾	11.50	17.08	19.54	21.86	26.12	30.33	32.52	34.66
3	⅞	16.00	23.76	27.18	30.40	36.32	42.18	45.23	48.20
4	⅝	4.33	6.43	7.35	8.22	9.83	11.41	12.24	13.04
4	¾	6.47	9.61	10.99	12.30	14.69	17.06	18.29	19.50
4	⅞	9.00	13.36	15.29	17.10	20.43	23.73	25.44	27.11
5	⅝	2.77	4.11	4.71	5.26	6.29	7.30	7.83	8.35
5	¾	4.14	6.15	7.03	7.87	9.40	10.92	11.71	12.48
5	⅞	5.76	8.55	9.78	10.94	13.08	15.19	16.28	17.35
6	⅝	..	2.86	3.27	3.66	4.37	5.07	5.44	5.80
6	¾	..	4.27	4.89	5.46	6.53	7.58	8.13	8.66
6	⅞	..	5.94	6.79	7.60	9.08	10.55	11.31	12.05
7	⅝	..	..	2.40	2.69	3.21	3.73	4.00	4.26
7	¾	..	..	3.59	4.01	4.80	5.57	5.97	6.37
7	⅞	..	..	4.99	5.58	6.67	7.75	8.31	8.85
8	⅝	..	..	..	2.06	2.46	2.85	3.06	3.26
8	¾	..	..	..	3.07	3.67	4.27	4.57	4.87
8	⅞	..	..	..	4.28	5.11	5.93	6.36	6.78

Spacings for superimposed loads other than 100 pounds per square foot may be found by proportion, thus:—

Required spacing $= \frac{100 + w''}{w' + w''} s$, in which,

s $=$ Spacing of tie rods from the table, in feet.
w' $=$ New load, in pounds per square foot.
w'' $=$ Weight of arch, in pounds per square foot.

The weights of tile arches per square foot are given on page 184.

Building codes frequently limit the spacing of tie rods.

REINFORCED CONCRETE BEAMS AND SLABS.

The following formulas and table dealing with reinforced concrete beams and slabs are based upon the generally accepted assumptions used in the theory of reinforced concrete design. The matter contained herein is restricted to simple rectangular beams and slabs reinforced for tension only.

A floor slab is considered as a wide beam, and in its design, it is usual to make the calculations for a unit of its width. The total area of reinforcing steel required is equal to that obtained for a unit width times the total width of the slab.

Placing of Reinforcing Steel. Parallel reinforcing bars should be spaced with a minimum clear distance of one and one-half diameters for round bars, and one and one-half times the diagonal for square bars. In no case should the spacing be less than one inch nor less than one and one-quarter times the maximum size of the coarse aggregate. Bars parallel to the face of the slab should be imbedded a minimum clear distance of one diameter from the face.

Slab Reinforced in Two Directions. In a rectangular panel, when the ratio of the longer side, l, to the shorter side, b, is less than 1.5, the slab should be reinforced in both directions, and the proportion of the load carried by the transverse reinforcement, parallel to the shorter side, b, can be found by the formula:—

$$r = \frac{l}{b} - 0.5$$

in which,

r = Proportion of the load carried by the transverse reinforcement, parallel to the shorter side, b.
l = Length of the longer side of the slab panel.
b = Length of the shorter side of the slab panel.

When the length of the panel is greater than 1.5 times the width, the load should be carried entirely by the transverse reinforcement, and longitudinal rods of about $\frac{1}{4}$ or $\frac{3}{8}$ inch in diameter should be placed from 18 inches to 24 inches apart to prevent shrinkage and temperature cracks.

Fire Protection. In fire-resistive construction, the reinforcing steel in the beams and girders should be protected by not less than 2 inches of concrete, and the reinforcing steel in the slabs should be protected by not less than one inch of concrete.

RECTANGULAR BEAMS AND SLABS WITH TENSION REINFORCEMENT ONLY.

NOTATION.

A_s = Effective area of steel in tension, in square inches.

b = Width of rectangular beam, in inches.

d = Depth from top or compression surface of beam or slab to center of gravity of longitudinal reinforcement, in inches.

f_c = Compressive unit stress in upper fiber of concrete, in pounds per square inch.

f_s = Tensile unit stress in steel reinforcement, in pounds per square inch.

j = Ratio of lever arm of resisting couple of beam or slab to depth, d.

k = Ratio of depth of Neutral Axis from top or compression surface of beam or slab to depth, d.

L = Span of beam or slab, in feet.

M = Bending Moment or Moment of Resistance, in inch pounds.

Σo = Sum of perimeters of bars, in inches.

p = Ratio of area of tension reinforcing steel to rectangle, bd, $= A_s \div bd$.

R = Constant $= f_s pj = \frac{1}{2} f_c kj$.

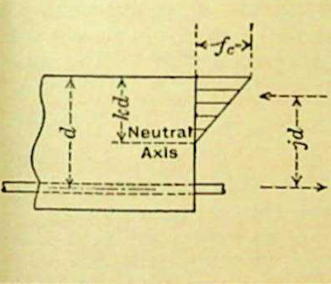
u = Bond stress per unit of area of surfaces of bars, in pounds per square inch.

v = Shearing unit stress of concrete, in pounds per square inch.

V = Total vertical shear on beam or slab, in pounds.

w = Uniformly distributed load, in pounds per square foot.

FORMULAS.



$M = Rbd^2$. (1) $f_s = \frac{M}{pjbd^2}$ . . (4)

$A_s = \frac{M}{f_s jd}$ . . . (2) $f_c = \frac{2M}{jkbd^2}$ . . (5)

$v = \frac{V}{bjd}$ . . . (3) $u = \frac{V}{jd\Sigma o}$ . . (6)

BENDING MOMENTS, IN INCH POUNDS, FOR SLIGHTLY RESTRAINED BEAMS AND SLABS.

Bending Moments of Beams and Slabs of One Span.

Maximum, Positive, at Center.

$M = 1.5\ wL^2$

Bending Moments of Beams and Slabs Continuous for Two Spans only.

Maximum, Positive, near Center.

$M = 1.2\ wL^2$

Maximum, Negative, over Interior Supports.

$M = 1.5\ wL^2$

Bending Moments of Beams and Slabs Continuous for More than Two Spans.

Maximum, Positive, near Center and, Negative, at Interior Supports.

$M = wL^2$

Maximum, Positive, near Center of End Spans and, Negative, at First Interior Support.

$M = 1.2\ wL^2$

WORKING STRESSES.

Concrete.

The following working stresses for concrete beams and slabs are given in percentages of the ultimate compressive strength of the concrete at the age of 28 days. This ultimate compressive strength in a 1:2:4 mixture having a good coarse aggregate is generally 2,000 pounds per square inch.

f_c = Compressive unit stress = 40 per cent of the ultimate compressive strength of the concrete at the age of 28 days.

u = Unit bond stress between concrete and plain bars = 4 per cent of the ultimate compressive strength of the concrete at the age of 28 days. For deformed bars this stress can be increased to 5 per cent of the ultimate.

v = Unit shearing stress, without web reinforcement = 2 per cent of the ultimate compressive strength of the concrete at the age of 28 days.

Steel Reinforcing Bars.

f_s = Unit tensile stresses for:—

Structural Steel Grade,—	16,000 pounds per square inch.
Intermediate Grade,—	18,000 pounds per square inch.
Hard Grade,—	18,000 pounds per square inch.

RATIOS AND CONSTANTS TO ACCOMPANY FORMULAS.

f_c	f_s	R	p	k	j
600	16,000	95.0	0.0068	0.360	0.880
	18,000	88.9	0.0056	0.333	0.889
650	16,000	107.5	0.0077	0.379	0.874
	18,000	100.5	0.0063	0.351	0.883
700	16,000	120.4	0.0087	0.396	0.868
	18,000	113.1	0.0072	0.368	0.877
750	16,000	133.5	0.0097	0.413	0.862
	18,000	125.7	0.0080	0.385	0.872
800	16,000	146.9	0.0107	0.429	0.857
	18,000	138.7	0.0089	0.400	0.867

The values in the table above correspond to a ratio of 15 between the modulus of elasticity of steel and that of concrete.

Example.

Design a reinforced concrete slab for an interior panel for the following conditions:— .

Slab continuous for more than two spans; $L = 7$ feet; Live load $= 150$ pounds per square foot; $f_c = 700$ pounds per square inch; $f_s = 18{,}000$ pounds per square inch.

Assume dead load of 70 pounds per square foot. Then the total load per square foot, $w = 150 + 70 = 220$ pounds per square foot.

Maximum Positive Bending Moment near center of slab panel, and Negative Bending Moment at interior supports.

$M = wL^2 = 220 \times 7^2 = 10{,}780$ inch pounds for a strip of slab 1 foot wide.

Referring to the table, when $f_c = 700$ and $f_s = 18{,}000$,
$R = 113.1$, $p = 0.0072$, $k = 0.368$, $j = 0.877$.

Substituting in Equation (1), $10{,}780 = 113.1 \times 12 \times d^2$ from which $d = 2.82$ inches.

The required area of steel, per foot width of slab, is obtained by equation (2) as follows:—

$$A_s = \frac{10{,}780}{18{,}000 \times 0.877 \times 2.82} = 0.242 \text{ square inches.}$$

$$\text{or } A_s = pbd = 0.0072 \times 12 \times 2.82 = 0.242 \text{ square inches.}$$

The nearest standard size of deformed bar to meet these conditions is a ⅜-inch round bar, spaced 5 inches center to center, giving an area of 0.26 square inches per foot of slab width.

Adding one-half the diameter of the bars to the effective depth, d, plus 1 inch for fire protection, the total depth of slab required is 4.00 inches.

The bars are laid 1 inch from the bottom of the slab where the Bending Moment is positive, and 1 inch from the top of the slab where the Bending Moment is negative. In order to prevent shrinkage and temperature cracks, bars ¼ or ⅜ inch in diameter should be placed running in a direction perpendicular to the main reinforcement and spaced 24 inches center to center.

Similarly, for stresses of 16,000 pounds per square inch in the steel and 650 pounds per square inch in the concrete a 4½-inch slab will be required, having reinforcing bars of the same size and spaced 6 inches center to center.

SHEARING AND BEARING VALUES OF RIVETS,

IN POUNDS.

Size of Rivet, Inch.	Area of Rivet, Square Inch.	UNIT STRESSES, POUNDS PER SQUARE INCH.							
		Shearing..........	8,000	9,000	10,000	11,000	12,000	13,500	13,500
		Bearing..........	16,000	18,000	20,000	22,000	24,000	27,000	30,000
3/8	.1104	Single Shear	880	990	1100	1210	1320	1490	1490
		Bearing, Inch.							
		3/16	1130	1270	1410	1550	1690	1900	2110
		1/4	1500	1690	1880	2060	2250	2530	2810
		Double Shear	1770	1990	2210	2430	2650	2980	2980
1/2	.1963	Single Shear	1570	1770	1960	2160	2360	2650	2650
		Bearing, Inch.							
		3/16	1500	1690	1880	2060	2250	2530	2810
		1/4	2000	2250	2500	2750	3000	3380	3750
		5/16	2500	2810	3130	3440	3750	4220	4690
		3/8	3000	3380	3750	4130	4500	5060	5630
		Double Shear	3140	3530	3930	4320	4710	5300	5300
5/8	.3068	Single Shear	2450	2760	3070	3370	3680	4140	4140
		Bearing, Inch.							
		3/16	1880	2110	2340	2580	2810	3160	3520
		1/4	2500	2810	3130	3440	3750	4220	4690
		5/16	3130	3520	3910	4300	4690	5270	5860
		3/8	3750	4220	4690	5160	5630	6330	7030
		7/16	4380	4920	5470	6020	6560	7380	8200
		Double Shear	4910	5520	6140	6750	7360	8280	8280
3/4	.4418	Single Shear	3530	3980	4420	4860	5300	5960	5960
		Bearing, Inch.							
		1/4	3000	3380	3750	4130	4500	5060	5630
		5/16	3750	4220	4690	5160	5630	6330	7030
		3/8	4500	5060	5630	6190	6750	7590	8440
		7/16	5250	5910	6560	7220	7880	8860	9840
		1/2	6000	6750	7500	8250	9000	10130	11250
		9/16	6750	7590	8440	9280	10130	11390	12660
		Double Shear	7070	7950	8840	9720	10600	11930	11930
7/8	.6013	Single Shear	4810	5410	6010	6610	7220	8120	8120
		Bearing, Inch.							
		1/4	3500	3940	4380	4810	5250	5910	6560
		5/16	4380	4920	5470	6020	6560	7380	8200
		3/8	5250	5910	6560	7220	7880	8860	9840
		7/16	6130	6890	7660	8420	9190	10340	11480
		1/2	7000	7880	8750	9630	10500	11810	13130
		9/16	7880	8860	9840	10830	11810	13290	14770
		5/8	8750	9840	10940	12030	13130	14770	16410
		11/16	9630	10830	12030	13230	14440	16240	18050
		Double Shear	9620	10820	12030	13230	14430	16240	16240

Bearing values given in small type are either smaller than single shear or larger than double shear.

SHEARING AND BEARING VALUES OF RIVETS,

IN POUNDS.

Size of Rivet, Inch.	Area of Rivet, Square Inch.	UNIT STRESSES, POUNDS PER SQUARE INCH.							
		Shearing..........	8,000	9,000	10,000	11,000	12,000	13,500	13,500
		Bearing..........	16,000	18,000	20,000	22,000	24,000	27,000	30,000
1	.7854	Single Shear	6280	7070	7850	8640	9420	10600	10600
		Bearing, Inch.							
		¼	4000	4500	5000	5500	6000	6750	7500
		5/16	5000	5630	6250	6880	7500	8440	9380
		⅜	6000	6750	7500	8250	9000	10130	11250
		7/16	7000	7880	8750	9630	10500	11810	13130
		½	8000	9000	10000	11000	12000	13500	15000
		9/16	9000	10130	11250	12380	13500	15190	16880
		⅝	10000	11250	12500	13750	15000	16880	18750
		11/16	11000	12380	13750	15130	16500	18560	20630
		¾	12000	13500	15000	16500	18000	20250	22500
		Double Shear	12570	14140	15710	17280	18850	21210	21210
1⅛	.9940	Single Shear	7950	8950	9940	10930	11930	13420	13420
		Bearing, Inch.							
		¼	4500	5060	5630	6190	6750	7590	8440
		5/16	5630	6330	7030	7730	8440	9490	10550
		⅜	6750	7590	8440	9280	10130	11390	12660
		7/16	7880	8860	9840	10830	11810	13290	14770
		½	9000	10130	11250	12380	13500	15190	16880
		9/16	10130	11390	12660	13920	15190	17090	18980
		⅝	11250	12660	14060	15470	16880	18980	21090
		11/16	12380	13920	15470	17020	18560	20880	23200
		¾	13500	15190	16880	18560	20250	22780	25310
		13/16	14630	16450	18280	20110	21940	24680	27420
		⅞	15750	17720	19690	21660	23630	26580	29530
		Double Shear	15900	17890	19880	21870	23860	26840	26840
1¼	1.2272	Single Shear	9820	11040	12270	13500	14730	16570	16570
		Bearing, Inch.							
		¼	5000	5630	6250	6880	7500	8440	9380
		5/16	6250	7030	7810	8590	9380	10550	11720
		⅜	7500	8440	9380	10310	11250	12660	14060
		7/16	8750	9840	10940	12030	13130	14770	16410
		½	10000	11250	12500	13750	15000	16880	18750
		9/16	11250	12660	14060	15470	16880	18980	21090
		⅝	12500	14060	15630	17190	18750	21090	23440
		11/16	13750	15470	17190	18910	20630	23200	25780
		¾	15000	16880	18750	20630	22500	25310	28130
		13/16	16250	18280	20310	22340	24380	27420	30470
		⅞	17500	19690	21880	24060	26250	29530	32810
		15/16	18750	21090	23440	25780	28130	31640	35160
		Double Shear	19640	22090	24540	27000	29450	33130	33130

Bearing values given in small type are either smaller than single shear or larger than double shear.

WEIGHTS OF STEEL RIVETS

WITH BUTTON HEADS.

FOR 100 RIVETS, IN POUNDS.

Length Under Head, Inches.	DIAMETER OF RIVET, INCHES.									
	½	9/16	⅝	11/16	¾	13/16	⅞	1	1⅛	1¼
1	10.0	15.2	18.3	21.7	26.6	..	..	..	..	..
1¼	11.4	16.8	20.3	24.5	29.5	37.0	46	60	..	..
1½	12.8	18.4	22.4	27.3	32.4	40.2	50	65	98	133
1¾	14.2	20.0	24.4	30.1	35.3	43.5	54	69	104	141
2	15.6	21.6	26.5	32.9	38.2	47.0	58	74	110	149
2¼	17.0	23.2	28.6	35.7	41.1	50.3	62	80	118	157
2½	18.4	24.8	30.6	38.5	44.0	53.5	66	86	124	165
2¾	19.8	26.4	32.7	41.3	46.9	56.8	70	92	130	173
3	21.2	28.0	34.7	44.1	49.8	60.0	74	98	137	181
3¼	22.6	29.7	36.8	46.9	52.7	63.3	78	103	144	189
3½	24.0	31.5	38.9	49.7	55.6	66.5	82	108	151	197
3¾	25.4	33.3	40.9	52.5	58.5	69.8	86	113	158	205
4	26.8	35.2	43.0	55.3	61.4	73.0	90	118	165	213
4¼	28.2	36.9	45.0	58.1	64.3	76.3	94	124	172	221
4½	29.6	38.6	47.1	60.9	67.2	79.5	98	130	179	229
4¾	31.0	40.3	49.2	63.7	70.1	82.8	102	136	186	237
5	32.4	42.0	51.2	66.5	73.0	86.0	106	142	193	245
5¼	33.8	43.7	53.3	69.2	75.9	89.3	110	148	200	254
5½	35.2	45.4	55.3	72.0	78.8	92.5	114	154	206	263
5¾	36.6	47.1	57.4	74.8	81.7	95.7	118	160	212	272
6	38.0	48.8	59.5	77.6	84.6	99.0	122	166	218	281
6½	40.8	52.0	63.6	83.3	90.4	105.5	130	177	231	297
7	43.6	55.2	67.7	88.9	96.2	112.0	138	188	245	314

WEIGHTS OF BUTTON HEADS AS MANUFACTURED, FOR 100 HEADS, IN POUNDS.

Button Heads.	DIAMETER OF RIVET, INCHES.									
	½	9/16	⅝	11/16	¾	13/16	⅞	1	1⅛	1¼
Pounds per hundred	3.9	6.0	7.9	11.3	14.1	17.7	21.6	31.3	45.5	63.6

WEIGHTS OF BOLTS

WITH SQUARE HEADS AND NUTS.

FOR 100 BOLTS, IN POUNDS.

Length Under Head, Inches.	DIAMETER OF BOLT, INCHES.								
	¼	5/16	⅜	½	⅝	¾	⅞	1	1⅛
1	2.6	4.7	7.5	16.1	29.6	47.2	72.7	....	....
1¼	3.0	5.2	8.3	17.5	31.4	50.3	77.0	....	....
1½	3.3	5.8	9.1	18.9	33.6	52.9	80.6	....	....
1¾	3.6	6.3	9.8	20.3	35.8	55.5	83.5	....	....
2	4.0	6.8	10.6	21.7	37.9	58.7	87.8	126.7	180.4
2¼	4.3	7.3	11.4	23.1	40.1	61.8	92.0	131.4	186.4
2½	4.6	7.8	12.1	24.5	42.3	64.9	96.3	137.0	193.4
2¾	5.0	8.4	12.9	25.9	44.4	68.1	100.5	141.6	198.2
3	5.3	8.9	13.7	27.2	46.6	71.2	104.8	147.2	205.3
3½	6.0	10.0	15.1	29.8	50.6	77.4	113.3	158.3	218.2
4	6.7	11.1	16.7	32.5	54.9	83.7	121.8	169.4	232.3
4½	7.4	12.2	18.2	35.3	59.3	89.4	129.7	179.7	245.3
5	8.1	13.3	19.8	38.1	63.6	95.7	138.2	190.8	259.4
5½	8.8	14.4	21.4	40.9	68.0	102.0	146.7	202.0	273.5
6	9.5	15.4	22.9	43.7	72.3	108.2	155.3	213.1	287.5
6½	10.2	16.5	24.5	46.5	76.7	114.5	163.8	224.2	301.6
7	10.9	17.6	26.1	49.2	81.0	120.7	172.3	235.3	315.7
7½	11.6	18.7	27.6	52.0	85.3	127.0	180.8	246.5	329.8
8	12.3	19.8	29.2	54.8	89.7	133.2	189.3	257.6	343.9
9	......	......	32.3	60.1	98.0	145.2	205.7	278.9	370.9
10	......	......	35.4	65.7	106.7	157.8	222.7	301.2	399.1
12	......	......	41.7	76.8	124.1	182.8	256.8	345.7	455.4
14	......	......	......	87.4	141.1	207.8	290.2	388.5	510.6
16	......	......	......	98.5	158.5	232.9	324.3	433.0	567.0
18	......	......	......	109.6	175.8	257.9	358.3	477.5	623.3
20	......	......	......	120.8	193.2	282.9	392.4	522.0	679.6
Per Inch Additional	1.4	2.2	3.1	5.6	8.7	12.5	17.0	22.3	28.2

WEIGHTS OF NUTS AND BOLT HEADS, IN POUNDS, FOR ONE HEAD AND ONE NUT.

DIAMETER OF BOLT, INCHES.	¼	5/16	⅜	½	⅝	¾	⅞
Square Head and Nut	.0149	.0288	.0495	.116	.225	.367	.584
Hexagon Head and Nut	.0129	.0251	.0430	.101	.194	.318	.505
DIAMETER OF BOLT, INCHES.	1	1⅛	1¼	1⅜	1½	1¾	2
Square Head and Nut	.874	1.31	1.79	2.37	3.06	4.86	7.22
Hexagon Head and Nut	.755	1.13	1.54	2.05	2.64	4.19	6.22
Weight of Shank per Inch ...	.223	.282	.348	.421	.501	.682	.890

All weights are theoretical.

NOTES ON RIVET SPACING.

The maximum pitch in the line of stress of compression members composed of plates and shapes shall not exceed 16 times the thinnest outside plate or shape nor 20 times the thinnest enclosed plate or shape. For best practice the maximum pitch is generally limited to 6 inches. The distance between lines of rivets at right angles to the direction of stress shall not exceed 30 times the thinnest plate or shape.

In built sections where plates are riveted to the leg of an angle, or an outstanding flange of a shape, by rivets staggered along two gage lines, the maximum pitch in the line of stress in each gage line shall not exceed 24 times the thinnest plate with a maximum of 12 inches.

Where heavy cover plates require that the rivet holes be drilled, the 6 inch pitch specified above may be increased to 8 inches and the 12 inch pitch specified above may be increased to 16 inches.

In tension members composed of two angles not in contact, the maximum spacing of washers should be 42 inches.

For compression members or struts composed of two angles not in contact, the following table gives the maximum spacing of washers:

24 inches if the sum of the widths of the legs of one angle is not over 7 inches;

36 inches if the sum of the widths of the legs of one angle is over 7 inches, but not exceeding 10 inches;

48 inches if the sum of the widths of the legs of one angle is over 10 inches.

However, the length between rivets divided by the least Radius of Gyration of one angle shall not be more than ¾ of the slenderness ratio, $\frac{l}{r}$, of the whole member.

For tension or compression members composed of two angles in contact, the distance between stitch rivets should not exceed

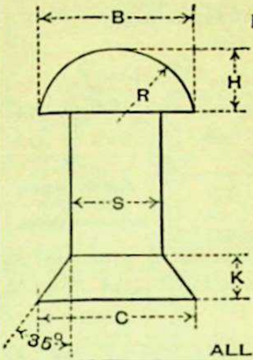
12 inches for material up to and including ¼ inch thick;

18 inches for material over ¼ inch thick.

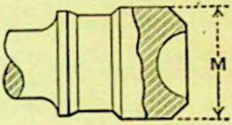
The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets for a length equal to 1½ times the maximum width of the member.

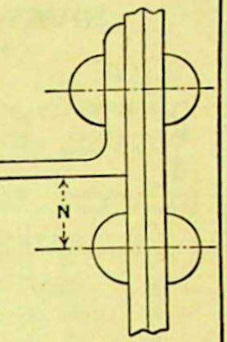
For the main material of girder work, columns with cover plates, etc., it is preferable to use rivets not less than ⅞ inch diameter where the material is over ¾ inch thick, or where three or more thicknesses have a total grip exceeding 1½ inches.

RIVET DIMENSIONS AND CLEARANCES.



STANDARD RIVET DIE.



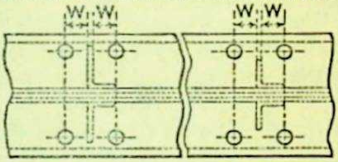


ALL DIMENSIONS IN INCHES.

Diameter of Rivet. S	BUTTON HEAD. Diameter. B	BUTTON HEAD. Height. H	BUTTON HEAD. Radius. R	COUNTERSUNK. Diameter. C	COUNTERSUNK. Height. K	Diameter of Die. M	CLEARANCE. Minimum. N	CLEARANCE. Preferred. N
1/2	7/8	3/8	7/16	7/8	17/64	1 7/8	7/8	1 1/8
5/8	1 3/32	15/32	9/16	1 1/16	5/16	2	7/8	1 1/8
3/4	1 5/16	9/16	21/32	1 1/4	23/64	2 1/4	1	1 1/4
7/8	1 17/32	21/32	25/32	1 7/16	13/32	2 1/2	1 1/8	1 3/8
1	1 3/4	3/4	7/8	1 5/8	29/64	2 3/4	1 1/4	1 1/2
1 1/8	1 31/32	27/32	1	1 13/16	1/2	3	1 3/8	1 5/8
1 1/4	2 3/16	15/16	1 1/8	2	17/32	3 1/4	1 1/2	1 3/4

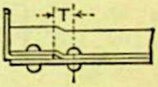
To obtain clearance required for a button head, add 1/8″ to height H.

CLEARANCE FOR COVER PLATE RIVETING.



Minimum W = 2 1/4″, preferably 2 1/2″.

RIVETS IN CRIMPED ANGLES.



Toe distance, T, should be 1 1/2″ plus thickness of the flange angle, but not less than 2″.

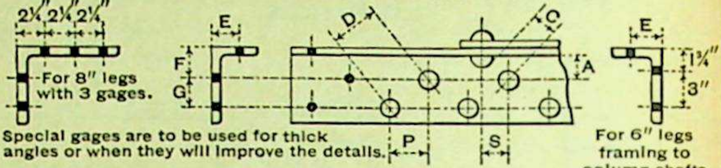
MINIMUM SPACING AND EDGE DISTANCE.

ALL DIMENSIONS IN INCHES.

Diameter of Rivet.	MINIMUM SPACING OF RIVETS.	MINIMUM EDGE DISTANCE. Sheared Edge.	MINIMUM EDGE DISTANCE. Rolled Edge.	MAXIMUM EDGE DISTANCE.
1/2	1 1/2, preferably 1 3/4	1	7/8	Eight times the thickness of the thinnest plate for material subjected to computed stress.
5/8	1 7/8, " 2	1 1/8	1	
3/4	2 1/4, " 2 1/2	1 1/4	1 1/8	
7/8	2 5/8, " 3	1 1/2	1 1/4	
1	3, " 3 1/2	1 3/4	1 3/8	
1 1/8	3 3/8, " 4	2	1 5/8	
1 1/4	3 3/4, " 4 1/2	2 1/4	1 7/8	

RIVET SPACING FOR ANGLES.

ALL DIMENSIONS IN INCHES.



Special gages are to be used for thick angles or when they will improve the details.

For 6" legs framing to column shafts.

STANDARD GAGES FOR ANGLES.

Leg.	8	7	6	5	4 1/2	4	3 1/2	3	2 1/2	2 1/4	2	1 3/4	1 1/2	1 1/4
E	4 1/2	4	3 1/2	3	2 1/2	2 1/2	2	1 3/4	1 3/8	1 1/4	1 1/8	1	7/8	3/4
F	3	2 1/2	2 1/2	1 3/4	..	..	..	..	..	..	..	..	..	..
G	3	3	2 1/4	2	..	..	..	..	..	..	..	..	..	..
Max. Rivet.	1 1/8	1	7/8	7/8	7/8	7/8	7/8	7/8	3/4	3/4	5/8	1/2	3/8	3/8

DISTANCE, D, OF STAGGERED RIVETS.

Gage. G	PITCH OF RIVETS, P.											
	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2
1	1 1/2	1 5/8	1 11/16	1 13/16	1 15/16	2	2 1/8	2 1/4	2 3/8	2 7/16	2 9/16	2 11/16
1 1/8	1 9/16	1 11/16	1 3/4	1 7/8	2	2 1/16	2 3/16	2 5/16	2 3/8	2 1/2	2 5/8	2 3/4
1 1/4	1 11/16	1 3/4	1 7/8	1 15/16	2 1/16	2 1/8	2 1/4	2 3/8	2 7/16	2 9/16	2 11/16	2 13/16
1 3/8	1 3/4	1 7/8	1 15/16	2 1/16	2 1/8	2 1/4	2 5/16	2 7/16	2 1/2	2 5/8	2 3/4	2 7/8
1 1/2	1 7/8	1 15/16	2 1/16	2 1/8	2 3/16	2 5/16	2 3/8	2 1/2	2 5/8	2 11/16	2 13/16	2 15/16
1 5/8	2	2 1/16	2 1/8	2 3/16	2 5/16	2 3/8	2 1/2	2 9/16	2 11/16	2 3/4	2 7/8	3
1 3/4	2 1/16	2 1/8	2 1/4	2 5/16	2 3/8	2 1/2	2 9/16	2 5/8	2 3/4	2 7/8	2 15/16	3 1/16
1 7/8	2 3/16	2 1/4	2 5/16	2 3/8	2 1/2	2 9/16	2 5/8	2 3/4	2 13/16	2 15/16	3	3 1/8
2	2 5/16	2 3/8	2 7/16	2 1/2	2 9/16	2 5/8	2 3/4	2 13/16	2 15/16	3	3 1/8	3 3/16
2 1/8	2 3/8	2 7/16	2 1/2	2 5/8	2 11/16	2 3/4	2 13/16	2 15/16	3	3 1/8	3 3/16	3 1/4
2 1/4	2 1/2	2 9/16	2 5/8	2 11/16	2 3/4	2 7/8	2 15/16	3	3 1/8	3 3/16	3 1/4	3 3/8
2 3/8	2 5/8	2 11/16	2 3/4	2 13/16	2 7/8	2 15/16	3	3 1/8	3 3/16	3 1/4	3 3/8	3 7/16
2 1/2	2 3/4	2 13/16	2 7/8	2 15/16	3	3 1/16	3 1/8	3 3/16	3 1/4	3 3/8	3 7/16	3 9/16

Values below and to the right of upper zigzag line are large enough for ¾" rivets.
Values below and to the right of lower zigzag line are large enough for ⅞" rivets.

MINIMUM STAGGER, S, FOR DRIVING.

Size of Rivet.	DISTANCE, A.												
	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 9/16	1 5/8	1 11/16	1 3/4	1 13/16	1 7/8
5/8	15/16	7/8	13/16	11/16	1/2	5/16	......	......	......	......	......	......	......
3/4	1 5/16	1 1/4	1 3/16	1 1/8	1	7/8	13/16	5/8	7/16	......	......	......	......
7/8	......	......	1 1/2	1 7/16	1 3/8	1 5/16	1 3/16	1 1/8	1	15/16	3/4	9/16	1/4
1	......	......	......	......	1 5/8	1 9/16	1 1/2	1 7/16	1 3/8	1 5/16	1 3/16	1 1/16	15/16
1 1/8	......	......	......	......	......	......	1 7/8	1 13/16	1 3/4	1 11/16	1 5/8	1 9/16	1 7/16

MINIMUM CLEARANCE, C.

Size of Rivet.	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Minimum Clearance, C.	15/16	15/16	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8

AREAS TO BE DEDUCTED TO OBTAIN NET AREA OF RIVETED MATERIAL.

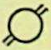
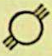
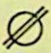
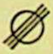
Diameter of punched hole = Diameter of rivet plus ⅛ inch.
Diameter of drilled or sub-punched and reamed hole } = Diameter of rivet plus $\frac{1}{16}$ inch.

CROSS-SECTIONAL AREA IN SQUARE INCHES.

Thickness of Metal, Inches.	DIAMETER OF HOLE, INCHES.												
	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1
1/16	.02	.02	.02	.03	.03	.04	.04	.04	.05	.05	.05	.06	.06
⅛	.03	.04	.05	.05	.06	.07	.08	.09	.09	.10	.11	.12	.13
3/16	.05	.06	.07	.08	.09	.11	.12	.13	.14	.15	.16	.18	.19
¼	.06	.08	.09	.11	.13	.14	.16	.17	.19	.20	.22	.23	.2
5/16	.08	.10	.12	.14	.16	.18	.20	.21	.23	.25	.27	.29	.3
⅜	.09	.12	.14	.16	.19	.21	.23	.26	.28	.30	.33	.35	.3
7/16	.11	.14	.16	.19	.22	.25	.27	.30	.33	.36	.38	.41	.4
½	.13	.16	.19	.22	.25	.28	.31	.34	.38	.41	.44	.47	.50
9/16	.14	.18	.21	.25	.28	.32	.35	.39	.42	.46	.49	.53	.56
⅝	.16	.20	.23	.27	.31	.35	.39	.43	.47	.51	.55	.59	.63
11/16	.17	.21	.26	.30	.34	.39	.43	.47	.52	.56	.60	.64	.68
¾	.19	.23	.28	.33	.38	.42	.47	.52	.56	.61	.66	.70	.75
13/16	.20	.25	.30	.36	.41	.46	.51	.56	.61	.66	.71	.76	.81
⅞	.22	.27	.33	.38	.44	.49	.55	.60	.66	.71	.77	.82	.88
15/16	.23	.29	.35	.41	.47	.53	.59	.64	.70	.76	.82	.88	.94
1	.25	.31	.38	.44	.50	.56	.63	.69	.75	.81	.88	.94	1.00

CONVENTIONAL SIGNS FOR RIVETING.

SHAPE OF HEAD.	SHOP RIVETS.		FIELD RIVETS.	
FULL BUTTON.	○	Both Sides.	●	Both Sides.
COUNTERSUNK AND CHIPPED.		Near side. (Outside.)		Near side. (Outside.)
	⊗	Far side. (Inside.)		Far side. (Inside.)
		Both sides.		Both sides.

SHAPE OF HEAD.	SHOP RIVETS.					
	To ⅛″ high; or countersunk and not chipped.		To ¼″ high; ½″ and ⅝″ rivets; ¾″ rivs., if necessary.		To ⅜″ high; ¾″ and ⅞″ rivets and 1″ rivets.	
FLATTENED.		Near side.		Near side.		Near side.
		Far side.		Far side.		Far side.
		Both sides.		Both sides.		Both sides.

DECIMALS OF A FOOT FOR EACH 32ND OF AN INCH.

Inch.	0″	1″	2″	3″	4″	5″
0	0	.0833	.1667	.2500	.3333	.4167
1/32	.0026	.0859	.1693	.2526	.3359	.4193
1/16	.0052	.0885	.1719	.2552	.3385	.4219
3/32	.0078	.0911	.1745	.2578	.3411	.4245
1/8	.0104	.0937	.1771	.2604	.3437	.4271
5/32	.0130	.0964	.1797	.2630	.3464	.4297
3/16	.0156	.0990	.1823	.2656	.3490	.4323
7/32	.0182	.1016	.1849	.2682	.3516	.4349
1/4	.0208	.1042	.1875	.2708	.3542	.4375
9/32	.0234	.1068	.1901	.2734	.3568	.4401
5/16	.0260	.1094	.1927	.2760	.3594	.4427
11/32	.0286	.1120	.1953	.2786	.3620	.4453
3/8	.0312	.1146	.1979	.2812	.3646	.4479
13/32	.0339	.1172	.2005	.2839	.3672	.4505
7/16	.0365	.1198	.2031	.2865	.3698	.4531
15/32	.0391	.1224	.2057	.2891	.3724	.4557
1/2	.0417	.1250	.2083	.2917	.3750	.4583
17/32	.0443	.1276	.2109	.2943	.3776	.4609
9/16	.0469	.1302	.2135	.2969	.3802	.4635
19/32	.0495	.1328	.2161	.2995	.3828	.4661
5/8	.0521	.1354	.2188	.3021	.3854	.4688
21/32	.0547	.1380	.2214	.3047	.3880	.4714
11/16	.0573	.1406	.2240	.3073	.3906	.4740
23/32	.0599	.1432	.2266	.3099	.3932	.4766
3/4	.0625	.1458	.2292	.3125	.3958	.4792
25/32	.0651	.1484	.2318	.3151	.3984	.4818
13/16	.0677	.1510	.2344	.3177	.4010	.4844
27/32	.0703	.1536	.2370	.3203	.4036	.4870
7/8	.0729	.1562	.2396	.3229	.4062	.4896
29/32	.0755	.1589	.2422	.3255	.4089	.4922
15/16	.0781	.1615	.2448	.3281	.4115	.4948
31/32	.0807	.1641	.2474	.3307	.4141	.4974

DECIMALS OF A FOOT FOR EACH 32ND OF AN INCH.

Inch.	6″	7″	8″	9″	10″	11″
0	.5000	.5833	.6667	.7500	.8333	.9167
1/32	.5026	.5859	.6693	.7526	.8359	.9193
1/16	.5052	.5885	.6719	.7552	.8385	.9219
3/32	.5078	.5911	.6745	.7578	.8411	.9245
1/8	.5104	.5937	.6771	.7604	.8437	.9271
5/32	.5130	.5964	.6797	.7630	.8464	.9297
3/16	.5156	.5990	.6823	.7656	.8490	.9323
7/32	.5182	.6016	.6849	.7682	.8516	.9349
1/4	.5208	.6042	.6875	.7708	.8542	.9375
9/32	.5234	.6068	.6901	.7734	.8568	.9401
5/16	.5260	.6094	.6927	.7760	.8594	.9427
11/32	.5286	.6120	.6953	.7786	.8620	.9453
3/8	.5312	.6146	.6979	.7812	.8646	.9479
13/32	.5339	.6172	.7005	.7839	.8672	.9505
7/16	.5365	.6198	.7031	.7865	.8698	.9531
15/32	.5391	.6224	.7057	.7891	.8724	.9557
1/2	.5417	.6250	.7083	.7917	.8750	.9583
17/32	.5443	.6276	.7109	.7943	.8776	.9609
9/16	.5469	.6302	.7135	.7969	.8802	.9635
19/32	.5495	.6328	.7161	.7995	.8828	.9661
5/8	.5521	.6354	.7188	.8021	.8854	.9688
21/32	.5547	.6380	.7214	.8047	.8880	.9714
11/16	.5573	.6406	.7240	.8073	.8906	.9740
23/32	.5599	.6432	.7266	.8099	.8932	.9766
3/4	.5625	.6458	.7292	.8125	.8958	.9792
25/32	.5651	.6484	.7318	.8151	.8984	.9818
13/16	.5677	.6510	.7344	.8177	.9010	.9844
27/32	.5703	.6536	.7370	.8203	.9036	.9870
7/8	.5729	.6562	.7396	.8229	.9062	.9896
29/32	.5755	.6589	.7422	.8255	.9089	.9922
15/16	.5781	.6615	.7448	.8281	.9115	.9948
31/32	.5807	.6641	.7474	.8307	.9141	.9974

DECIMALS OF AN INCH FOR EACH 64TH, WITH MILLIMETRE EQUIVALENTS.

Fraction.	1/64ths.	Decimal.	Millimetres.	Fraction.	1/64ths.	Decimal.	Millimetres.
....	1	.015625	0.397	....	33	.515625	13.097
1/32......	2	.03125	0.794	17/32....	34	.53125	13.494
....	3	.046875	1.191	....	35	.546875	13.891
1/16......	4	.0625	1.588	9/16......	36	.5625	14.288
....	5	.078125	1.984	....	37	.578125	14.684
3/32......	6	.09375	2.381	19/32....	38	.59375	15.081
....	7	.109375	2.778	....	39	.609375	15.478
1/8......	8	.125	3.175	5/8......	40	.625	15.875
....	9	.140625	3.572	....	41	.640625	16.272
5/32......	10	.15625	3.969	21/32....	42	.65625	16.669
....	11	.171875	4.366	....	43	.671875	17.066
3/16......	12	.1875	4.763	11/16....	44	.6875	17.463
....	13	.203125	5.159	....	45	.703125	17.859
7/32......	14	.21875	5.556	23/32....	46	.71875	18.256
....	15	.234375	5.953	....	47	.734375	18.653
1/4......	16	.25	6.350	3/4......	48	.75	19.050
....	17	.265625	6.747	....	49	.765625	19.447
9/32......	18	.28125	7.144	25/32....	50	.78125	19.844
....	19	.296875	7.541	....	51	.796875	20.241
5/16......	20	.3125	7.938	13/16....	52	.8125	20.638
....	21	.328125	8.334	....	53	.828125	21.034
11/32....	22	.34375	8.731	27/32....	54	.84375	21.431
....	23	.359375	9.128	....	55	.859375	21.828
3/8......	24	.375	9.525	7/8......	56	.875	22.225
....	25	.390625	9.922	....	57	.890625	22.622
13/32....	26	.40625	10.319	29/32....	58	.90625	23.019
....	27	.421875	10.716	....	59	.921875	23.416
7/16......	28	.4375	11.113	15/16....	60	.9375	23.813
....	29	.453125	11.509	....	61	.953125	24.209
15/32....	30	.46875	11.906	31/32....	62	.96875	24.606
....	31	.484375	12.303	....	63	.984375	25.003
1/2......	32	.5	12.700	1........	64	1.	25.400

INDEX.

Page

Advantages of Bethlehem wide flange shapes 5
Allowable stresses—see Stresses, allowable.
  variation in weights of sections 8
Angles, connection, for Bethlehem Girder Beams 125, 127, 129
  " for Bethlehem I Beams 131, 133, 135
  " minimum spans for Bethlehem Girder Beams with 136–137
  " minimum spans for Bethlehem I Beams with 138–139
  gages and maximum sizes of rivets in 202
  spacing of rivets in 200–202
Arches, fireproof floor, notes and tables for 183–184
  hollow tile floor, explanation of tables of safe loads for 186–187
  " " " illustrations of typical 185
  " " " tables of safe loads for 187–188
  " " " weights of 184
  thrust of, notes on 189–190
  tie rods for, notes and tables for spacing 190–191
Area, reduction of, for rivet holes 203
Areas of Bethlehem Structural Shapes, method of increasing sectional 4

Bases, typical details of column 142–144, 147–149
Beam girders, comparison of, with Bethlehem Girder Beams 52–53
Beams, bearing plates for, notes on 173–174
  " " " tables of 175
  built-up separators for 140–141
  coefficients of deflection for, notes and tables on 164–165
  connections for, details of 124–135
  " " illustrations of 142, 143, 146
  diagrams and formulas for moments, shears and deflections of 166–169
  general formulas for flexure of 150–155
  grillage, for foundations, notes on 170–172
  laterally unsupported, notes on 74
  " " reduction in safe loads and allowable fiber stresses for 75
  moments, shears and deflections of, notes on 150–165
  reactions of, notes on 93
Beams, Bethlehem Girder:
  areas of 40, 42
  bearing plates for, table of 175
  bending moments for, tables of allowable 48–49
  comparison of, with girders of standard beams 52–53
  connection angles for 125, 127, 129
  crippling strength of webs of, notes on 93–94
  " " " " " table of 95
  detailing dimensions for 124–129
  drawings of sections of 9–16

Page
Beams, Bethlehem Girder, cont'd.
explanatory notes on 5
laterally unsupported, notes on 74–75, 84
maximum laterally unsupported length of 84
" size of rivets in flanges of 124, 126, 128
minimum spans of, with double connection angles 136–137
" " safe, based on strength of webs 95
moments of resistance for 48–49
properties of, explanation of tables of 34–39
" " tables of 40–43
safe loads for, explanation of tables of 74–76
" " " tables of 77–83
" " " used as columns 102–105
" shear on webs of, explanation of tables of 93–94
" " " " " tables of 95
separators, built-up, for 140
standard gages for rivet holes in 124–129
wall plates for, table of 175
weights, dimensions and profiles of 9–16
Beams, Bethlehem I:
areas of 44, 46
bearing plates for, table of 175
bending moments for, tables of allowable 50–51
comparison of, with standard beams 54–55
connection angles for 131, 133, 135
crippling strength of webs of, notes on 93–94
" " " " " table of 96
detailing dimensions for 130–135
drawings of sections of 17–25
explanatory notes on 6
laterally unsupported, notes on 74–75, 92
maximum laterally unsupported length of 92
" size of rivets in flanges of 130, 132, 134
minimum spans of, with double connection angles 138–139
" " safe, based on strength of webs 96
moments of resistance for 50–51
properties of, explanation of tables of 34–39
" " tables of 44–47
safe loads for, explanation of tables of 74–76
" " " tables of 85–92
" " " used as columns 106–109
" shear on webs of, explanation of tables of 93–94
" " " " " tables of 96
separators, built-up, for 141
standard gages for rivet holes in 130–135
wall plates for, table of 175
weights, dimensions and profiles of 17–25
Bearing plates, notes on 173
" tables of 175
Bearing values for brickwork and masonry 174
" of rivets 196–197
Bending factors, example 99
" explanation of 39, 98
" values of, for Bethlehem Columns, Supplementary Sections 65, 67

Page

Bending factors, cont'd.
" values of, for Bethlehem H Columns . 57, 59, 61, 63
" " " " Bethlehem Girder Beams . . 103, 105
" " " " Bethlehem I Beams 107, 109
" " " " Reinforced 14″ H Columns 71
" " " " Special Compound Columns 73
Bending moment diagrams for beams 166–168
" explanation of 160
moments for reinforced concrete beams and slabs 194
" " various methods of loading 166–169
" maximum allowable, for Girder Beams 48–49
" " " " Beth. I Beams 50–51
Bethlehem Structural Shapes, explanatory notes on 3–7
" " method of increasing sectional area of 4
Bolts and nuts, weights of 199
for beam separators 140–141
Book tile, weight of 184
Brackets for columns, typical details of 143, 145, 147–149
Buckling stresses in beam webs, notes on 162

Clearances for machine driven rivets 201–202
Coefficients of deflection for beams, explanation of 164
" " " " table of 165
" strength, explanation of 35, 152, 159
" " of Girder Beams, values of 40–43
" " " Bethlehem I Beams, values of 44–47
Column bases, illustrations of typical 144
" notes on 172
Columns, Bethlehem Girder Beams used as 102–105
Bethlehem I Beams used as 106–109
Bethlehem, notes on 6
Columns, Bethlehem H:
bases for, typical details of 144
details of, typical 142–144
dimensions of, tables of 56–63
drawings of sections of 26–29
example showing method of selecting 101
properties of, explanation of tables of 37–39
" " tables of 56–63
reinforced—see Columns, Reinforced 14″ H.
safe loads for, explanation of tables of 97–101
" " " tables of 110–117
special H section, 14″, uses and properties of . . . 68–69
weights of 56–63
Columns, Bethlehem, Supplementary Sections:
dimensions of, tables of 64–67
drawings of sections of 30–33
explanatory notes on 7
properties of, tables of 64–67
safe loads for, tables of 118–119
weights of 64–67
Columns, eccentric loads on 39, 99

Page

- Columns, Reinforced 14″ H:
  - dimensions and properties of, tables of 70–71
  - explanatory notes on 68
  - safe loads for, tables of 120–121
  - weights of 70, 120
- Columns, Special Compound:
  - dimensions and properties of, tables of 72–73
  - explanatory notes on 68
  - safe loads for, tables of 122–123
  - weights of 72, 122
- Comparison of Bethlehem Girder Beams with girders of standard I beams 52–53
  - " Bethlehem I Beams with standard I beams 54–55
- Concrete, notes on reinforced 192–195
- Connection angles for Bethlehem Girder Beams 125, 127, 129
  - " " Bethlehem I Beams 131, 133, 135
  - " minimum spans for beams with 136–139
- Crippling strength of beam webs, notes on 93–94
  - " " " " tables of 95–96
- Cutting to length, allowable variation in 8

- Decimals of a foot, for each $\frac{1}{32}$ of an inch 204–205
  - of an inch, for each $\frac{1}{64}$ 206
- Deflection coefficients, notes on 164–165
  - limits for plastered ceilings 76
  - of beams, formulas for 154, 166–168
  - " " notes on 162–164
- Design of bearing plates for beams 173–175
  - " columns 97–101, 158
  - " grillage beams in foundations 170–172
  - " I beams and girders 36, 75, 94, 156–165
  - " reinforced concrete floor slabs 192–195
  - " tie rods 189–191
  - " wind bracing in tall buildings 176–181
- Detail dimensions for Bethlehem Girder Beams 124–129
  - " " Bethlehem I Beams 130–135
- Details, typical, for beams and columns 142–149
- Diagrams and formulas for beams and loadings 166–169
- Dimensions and properties of Bethlehem Structural Shapes, explanation of tables of 34–39
  - of Bethlehem Columns 26–33, 56–72
  - " Bethlehem Girder Beams 9–16
  - " Bethlehem I Beams 17–25
  - " rivet heads 201

- Eccentric loads on columns 99
- Edge distance for riveting 201
- Example illustrating calculation of safe loads on arches 187
  - " concrete slab design 195
  - showing method of selecting Bethlehem Columns 101
  - " use of bending factors 99
- Explanatory notes on Bethlehem Structural Shapes 3–7

Page

Fiber stress, allowable—see Stresses, allowable.
Fireproof floors and materials, notes and tables for..... 182–195
Flexure, lateral, in beams, due to thrust of arches....... 189
" notes on.......................... 74–75
" of beams, formulas for.............. 75
" reduction of allowable stress due to...... 75
vertical, of beams, notes on................ 156–165
Floor arches, safe loads for......................... 187–188
" table of weights of..................... 184
framing, typical illustrations of................ 142
slabs, reinforced concrete, notes on design of....... 192–195
Floors, notes and tables for fireproof................. 182–195
Foot, fractions of an inch in decimals of a.............. 204–205
Footings, notes on grillage beams for................. 170–172
Formulas for bending moments in beams............153, 166–169
" " " " " or slabs, reinforced concrete 193
" deflection of beams due to impact.......... 163
" " " " under quiescent loads. 154, 166–168
" grillage beams in foundations............. 171
" moments of resistance of beams........... 152, 159
" moving loads on beams.................. 169
" safe loads on beams...............76, 153, 166–168
" shear in beams........94, 153, 155, 161–162, 166–169
" stress in beams due to impact............. 163
" " due to lateral thrust of arches....... 189
" stresses in bearing plates for beams........ 173
" " " columns.......................... 97
" " " " due to eccentric loads.... 39
" " " " " " wind loads........ 179–181
" " " compression flanges of beams...... 75
" " " girders due to wind loads......... 179–181
" tie rods, spacing of..................... 190
" wind stresses in tall buildings............ 179–181
general, for flexure of beams................. 152–155
Foundations, notes on grillage beams in................ 170–172
Fractions of an inch in decimals of a foot.............. 204–205
" " " " " " an inch............. 206
Furring, notes on tile................................. 183
weights of split tile........................ 184

Gages for rivet holes in angles......................... 202
" " " " Bethlehem Girder Beams.....124, 126, 128
" " " " Bethlehem I Beams..........130, 132, 134
General conditions...................................... 8
Girders of two standard beams, comparison of, with Bethlehem Girder Beams....................... 52–53
Grey Universal Structural Mill, explanatory notes on...... 3–4
Grillage beams for foundations, illustrations of typical... 144
" " " notes on............. 170–172
Grip of rivets and bolts through flanges of beams and girders 124–134

H Columns—see Columns, Bethlehem H.
Heads, rivet, dimensions of............................ 201
Hollow tile floor arches, see Arches.

Page

Impact, formulas for stresses and deflections in beams due to 163
Inch, decimals of, for each 1/64, tables of 206
  equivalents in millimetres 206
Inches and fractions in decimals of a foot 204–205

Laterally unsupported length, max., for Girder Beams 84
  “ “ “ “ Bethlehem I Beams 92
Lateral strength of I beams, notes on 74–75
Length, allowable variation in cutting to 8

Masonry, safe bearing values for 174
Maximum shear for beams of uniform section, formulas for 155, 166–169
  “ “ Bethlehem Girders and I Beams based upon web strength 95–96
Method of rolling Bethlehem Structural Shapes 3
Mill building construction, illustrations of typical 147–149
Millimetre equivalents of inch fractions 206
Minimum spans for Bethlehem Girders and I Beams based upon web strength 95–96
  “ “ Bethlehem Girders and I Beams with double connection angles 136–139
Moment of inertia, explanation of 156
  “ “ formula for 152, 157
  “ resistance, explanation of 159
Moments of resistance for Bethlehem Girders and I Beams, tables of 48–51
Moments, bending, for beams of uniform section . . . 153, 160, 166–169
Moving loads on beams (See also Impact) 169

Neutral axis, explanation of 157
Nuts and bolts, weights of 199

Partitions, weights and dimensions of hollow tile for 184
Plastered ceilings, deflection limits for 76
Plate and angle separators for Bethlehem Girders and I Beams 140–141
Plates, bearing, for Bethlehem Girders and I Beams, table 175
  riveted, areas of holes to be deducted to obtain net areas of 203
  “ tables of bearing values for rivets in 196–197
Profiles of Bethlehem Structural Shapes 9–33, 68
Properties of Bethlehem Columns, tables of 57–73
  “ Bethlehem Girder Beams, tables of 40–43
  “ Bethlehem I Beams, tables of 44–47
  “ Bethlehem Structural Shapes, explanation of tables of 34–39
  “ sections, notes on 156–160

Radius of gyration, explanation of 34, 158
Ratio of slenderness, explanation of 38
  “ “ limiting values of 98, 200
Reactions, safe, based on strength of beam webs 95–96
  “ “ “ “ “ end connections 125–135

Page

REINFORCED concrete, allowable unit stresses for 194
" beams and slabs, notes on......... 192–195
RIVET and bolt grips in flanges of Bethlehem Girders and I Beams.............................. 124–135
holes, reduction of area for..................... 203
RIVETS, clearances for machine driven................ 201–202
conventional signs for........................ 203
dimensions of heads of....................... 201
maximum sizes of, in angles.................... 202
" " " " Bethlehem Girders and Beams 124–135
shearing and bearing values of................. 196–197
spacing of, general rules for.................. 200
" " tables for..................... 202
weights of................................ 198

SAFE loads for beams, formulas and diagrams for.....153, 166–169
" " beams, laterally unsupported, reduction of.. 75
" " Bethlehem Columns, notes on............ 97–98
" " " " supplementary sections, tables of..... 118–119
" " Bethlehem Girders and I Beams, based upon web strength, tables of................ 95–96
" " Bethlehem Girders and I Beams, notes on. 74–76
" " " " " " " tables of. 77–83
" " " " used as Columns...... 102–105
" " " H Columns, tables of......... 110–117
" " " I Beams, tables of............ 85–91
" " " " " used as columns..... 106–109
" " hollow tile floor arches, explanation of tables of... 186–187
" " " " " " tables of...... 187–188
" " reinforced 14″ H columns, tables of........ 120–121
" " Special Compound Columns, tables of..... 122–123
SECTION moduli for beams, explanation of.............. 157
SEPARATORS, built up, for Bethlehem Girder Beams and I Beams 140–141
SHEAR and shearing stresses, notes on.....93, 153, 155, 161, 166–169
SHEAR diagrams for beams......................... 166–168
SHEAR, safe, on beams, formula for 94, 153
" " Bethlehem Girder Beams, table of 95
" " Bethlehem I Beams, table of 96
" " rivets, table of...................... 196–197
SHEARING values of rivets, tables of.................. 196–197
SLABS, reinforced concrete, notes on.................. 192–195
steel, for column bases, notes on................ 172
SLOPE of flanges of Bethlehem Structural Shapes......... 7
SPACING of rivet and bolt holes in angles............... 202
" rivets in bridge and structural work, rules for... 200
" " tables of......................... 202
" tie rods for tile arches..................... 190–191
SPANDREL framing, illustrations of typical.............. 145
SPANS, limiting, based on web strength of Bethlehem Girders and I Beams, tables of............ 95–96
" for Bethlehem Girders and I Beams with connection angles................. 136–139

Page

Special Compound Columns, dimensions and properties of 72–73
" " notes on.................. 68
" " safe load tables for........ 122–123
Special H section, Bethlehem 14″.................. 68–69
Splices for columns, illustrations of typical....... 142, 143, 147–149
Split furring, notes on.......................... 183
" weight of.......................... 184
Stresses, allowable, combined, due to wind and other loads 176
" for concrete beams and slabs........ 194
" " steel rivets in shear and bearing.. 124, 196
" " " tension reinforcement in concrete beams and slabs..... 194
" " structural steel in bending in beams laterally supported.. 35–36
" " " steel in bending in beams laterally unsupported 75
" " " steel in compression in columns............ 97–98
" " " steel in shear in beam webs.............. 94
Supplementary Columns—see Columns, Bethlehem, Supplementary Sections.

Thrust of floor arches, notes on.................. 189
Tie rods, sizes of.............................. 190
" spacing of.............................. 191
Tolerances for weights and cutting to length............ 8
Typical framing details, illustrations of................ 143–149

Variation in profiles and weights, method of obtaining... 4
Variations for Bethlehem Structural Shapes, allowable... 8

Wall bearing plates for Bethlehem Girders and I Beams, tables of..................... 175
" " notes on........................ 173–174
Web crippling in beams, notes on.................. 93–94
Weight of steel.............................. 7
Weights of beams, Bethlehem Girder................ 9–16
" " Bethlehem I.................... 17–25
" bearing plates for beams.................. 175
" Bethlehem Columns, supplementary sections.. 64–67
" Bethlehem Columns, Special Compound...... 72
" Bethlehem H Columns.................. 56–63
" Bethlehem H Columns, Reinforced 14″....... 70
" bolts, bolt heads and nuts.................. 199
" connection angles for Bethlehem Girders and I Beams.............................. 125–135
" hollow tile floor arches and fireproof materials 184
" separators, built up, and bolts for Bethlehem Girders and I Beams.................. 140–141
" steel rivets and rivet heads................ 198
" Structural Shapes, allowable variation in..... 8
Wind bracing connections, illustrations of typical........ 143
stresses in tall buildings, notes on................ 176–181

BETHLEHEM STEEL COMPANY

General Offices

BETHLEHEM, PENNSYLVANIA

District Offices

Atlanta	Healey Building
Boston	Atlantic National Bank Building
Baltimore	Continental Building
Buffalo	Marine Trust Building
Chicago	People's Gas Building
Cincinnati	Union Trust Building
Cleveland	Union Trust Building
Detroit	Penobscot Building
Houston	Keystone Building
Los Angeles	Pacific Finance Building
New York	Cunard Building
Philadelphia	Widener Building
Pittsburgh	Oliver Building
St. Louis	Chemical Building
San Francisco	Matson Building
Seattle	L. C. Smith Building

Bethlehem Steel Export Corporation

25 Broadway, New York City

Sole Exporter of Our Commercial Products

BETHLEHEM STEEL COMPANY.

BETHLEHEM, PA.

PARTIAL LIST OF PRODUCTS.

Structural Steel Shapes: Bethlehem Beams, Rolled Girder Beams and Rolled Columns; Standard Beams, Channels and Angles; Standard and Special T and Z Bars; Plain and Fabricated; Crane Rails; Rolled Steel Slabs for Column Bases.

Shipbuilding Shapes: Ship Channels, Bulb Angles, and Hatch Sections.

Car Building Shapes: Beams, Channels, Angles, Bulb Angles, Z Bars, Center and Side Sill Sections, Belt Rail, Door Spreader, and Side Stake Sections.

Plates: Universal and Sheared; Circular (Heads), in all grades for all purposes; Miscellaneous Pressed Work.

Piling: Lackawanna Steel Sheet Piling.

Bridges and Fabricated Buildings: Designers, Builders, Fabricators and Erectors of all types of Bridges and Steel Structures. Buckle Plates.

Railroad Turntables: Bethlehem Twin-Span Turntables; Balanced and Continuous Turntables.

Pig Iron: Standard Grades, Special Grades and Mayari.

Ferro-Manganese, Spiegeleisen, Coke and Coke By-Products.

Billets, Blooms, Slabs and Skelp.

Bars and Bands: Muck Bar, Refined, Double Refined Iron; Bessemer, Open Hearth, Electric Alloy Steel; Concrete Reinforcing Bars; Sheet Bars.

Sheet and Tin Mill Products: Roll Roofing.

Machinery: Hydraulic Machinery and equipment; Special Machinery of all types and designs.

Pulverizers for Coal and Other Materials.

Engines: Pumping Engines for Municipal Purposes; Blowing, Producer Gas, Gas, and Diesel Oil Engines.

Gears and Pinions: Cut and Cast; Bridge Operating Machinery.

Rolls: Carbon and Alloy Steel.

Boiler Tubes: Lap Welded; Charcoal Iron, and Steel.

Steel and Composite Freight Cars, Rolled Steel Car Wheels.

Steel Axles: For Passenger and Freight Cars, Engine and Tender Trucks; Driving; Motor; Electric and Mine Car; etc.

Auxiliary Locomotives.

Rails and Accessories, Frogs and Switches.

Industrial and Mine Track Work, Steel Mine Ties.

Flanged and Dished Boiler Heads, Special Flanged Products.

Tool Steel for Every Purpose: Bethlehem Special High-Speed Tool Steel; Non-shrinkable; Rock and Mine Drill Steel; Special Tool Steels; Small Tools, etc.

Rolled Steel Blanks for Gears, Pinions, Fly Wheels, Etc.

Castings: Steel, Iron, Brass and Bronze; Centrifugal Castings.

Ingot Moulds: All sizes.

Forgings: Drop, Hammered and Hydraulically Pressed; All sizes and types; Forged Shafts.

Bolts, Nuts, Rivets, Spikes, Pole Line Material.

Special Steel for Automobile Forgings and Machined Parts.

Motor Truck Wheels, Rolled Steel.

Wire Rods, Wire Nails, Wire, Woven Wire Field and Poultry Fencing.

Agricultural Steel and Specialties: Standard and Special Shapes.

Gas and Steaming Coal.

Ordnance Material of Every Description.

PLANTS AT

Bethlehem, Pa.; Lebanon, Pa.; Johnstown, Pa.;
Coatesville, Pa.; Steelton, Pa.; Lackawanna, N. Y.;
Sparrows Point, Md.

Printed in the U. S. A.

FRED J. GRADOUS.
5875 N. KOLMAR AVE: